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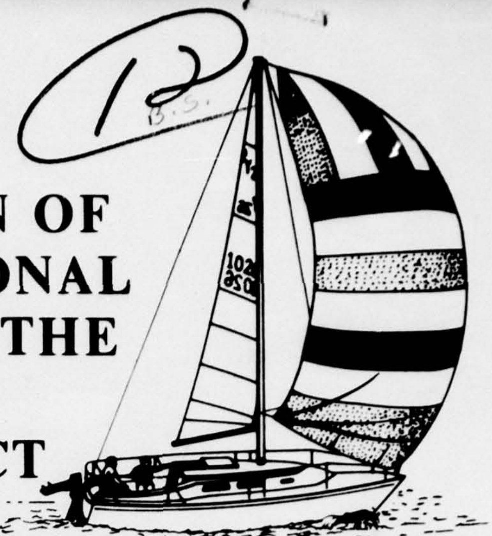
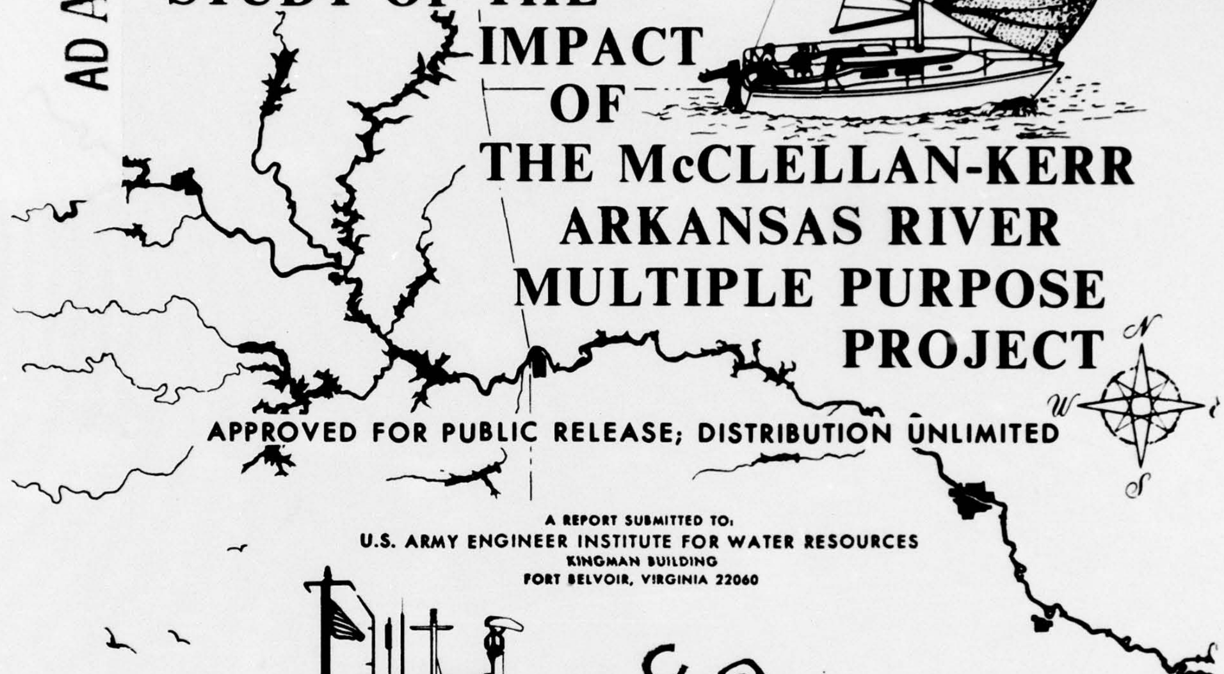


AN APPLICATION OF THE INTERREGIONAL I/O MODEL FOR THE STUDY OF THE IMPACT OF THE McCLELLAN-KERR ARKANSAS RIVER MULTIPLE PURPOSE PROJECT



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MARCH 1977

IWR CONTRACT REPORT 77-2

AN APPLICATION OF THE INTERREGIONAL I/O MODEL FOR THE STUDY OF THE IMPACT OF THE McCLELLAN-KERR ARKANSAS RIVER MULTIPLE PURPOSE PROJECT

A Report Submitted to:

US Army Engineer Institute for Water Resources
Kingman Building
Fort Belvoir, Virginia 22060

Under

Contract No. DACW31-74-C-0047

By

Dr. Ungsoo Kim
Assisted by Dr. Cheol Park
& Dr. Sang Kyung Kwak

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MARCH 1977

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This report is one of a series examining the impacts of the completed McClellan-Kerr Arkansas River Navigation System. The primary objective of this contract study was to apply the Interregional Input-Output Model of the United States, developed for the Economic Development Administration by Harvard University to the assessment of the impacts of constructing the McClellan-Kerr project. The model will also be used to assess the economic and spatial impacts of recreation and navigation among other project outputs.

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The gross direct and indirect construction impact of the project was estimated by the Interregional Input-Output Model to be $6.4 billion in output and $2.1 billion in household income in 1963 dollars. Of this amount, apparently 35.8 percent of the output and 52 percent of the income are estimated to be shared by the project region. This assessment is based on essentially short-term construction impacts and does not represent net increments of national income. Other more enduring benefits and costs will be obtained through the functional outputs of the McClellan-Kerr Arkansas River Navigation System--transportation, flood control, water supply, electric power, sediment control and channel stabilization, recreation and fish and wildlife enhancement.

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FOREWARD

This report is one of a series examining the impacts of the completed McClellan-Kerr Arkansas River Navigation System. The primary objective of this contract study was to apply the Interregional Input-Output Model of the United States, developed for the Economic Development Administration by Harvard University to the assessment of the impacts of constructing the McClellan-Kerr project. The model will also be used to assess the economic and spatial impacts of recreation and navigation among other project outputs.

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This report presents a careful description of the model used, the assumptions adopted, the procedures for adapting the national Input-Output Model to project evaluation and the programs and data summaries for all major steps of analysis. The model is operational on Corps of Engineers computer equipment and available for adaptation to other project studies with relatively modest investment.

Other published reports in the series on impact of the McClellan-Kerr Arkansas River Navigation System include:

IWR Research Report 75-R3, An Overview of the Impact Study of the McClellan-Kerr Multiple Purpose Arkansas River System, Jul 75.

IWR Contract Report 74-5, Regional Response Through Port Development: An Economic Case Study on the McClellan-Kerr Arkansas River Project, Aug 74.

IWR Contract Report 74-6, Evaluation of Interregional Input-Output Models for Potential Use in the McClellan-Kerr Arkansas River Multiple Purpose Project Impact Study, Aug 74.

IWR Research Report 74-R2, Discriminant Analysis Applied to Commodity Shipments in the Arkansas River Area, Aug 74.

Chapter I

Introduction

The McClellan-Kerr Arkansas River Multiple Purpose Project (MKARMPP), as a federal water resource development project for the Arkansas River Valley area, was originated in 1946 under the responsibility of the Army Corps of Engineers. The purpose of the project was to develop the Arkansas River Valley through the control of floods, the supply of water and electric power, and the improvement of the navigation of the Arkansas River as far as Tulsa, Oklahoma. As the resource development projects evolve, there will emerge a wide range of impacts which will have a significant bearing on economic, political, social, and environmental conditions within the immediate river valley area. This area is considered as the project impact region and includes over 60 countries in the OBE functional areas of 117, 118, and 119. In addition to the project impact on the project region, the impact on the neighboring areas is also significant either by direct influence or through trade with the impact region. Therefore, the impact study of the MKARMPP should encompass a comprehensive effect of the project on the project region as well as those on neighboring regions with which the impact region has trade relationships.

Purpose of the Study

The purpose of this study is to analyze the economic impact of the McClellan-Kerr Arkansas River Multiple Purpose Project. The economic impact will be measured in terms of the increase in output and income resulting from the construction expenditures of MKARMPP on local and national economies and on interindustry and interregional relationships.

Some of the specific objectives of this study are: (1) to construct an interregional I/O model for the impact study; (2) to convert the MKARMPP cost into regional final demand vectors; (3) to estimate the direct and indirect and induced construction impact of the MKARMPP in terms of output and income; and (4) to provide a sensitivity analysis of the model.

Organization of the Study

In the following chapter, we present the basic model for this impact study, which is an interregional input-output model.

In Chapter III, the basic data required for this I/O model are estimated. These data include: (1) regional technical coefficients; (2) trade coefficients; (3) regional household income and expenditure coefficients; and (4) regional final demands.

An analysis and evaluation of the impact of MKARMPP are presented in Chapter IV. A brief explanation is given to various kinds of multipliers. A sensitivity analysis is also included in this chapter. In the sensitivity analysis, a comparative evaluation of the investment impact resulting from the hypothetical change in project type holding the project region constant and vice-versa is attempted.

In the last chapter we will summarize the overall study and some concluding remarks will follow. Statistical data, formulae, and computer programs which complement the main explanation are included in the Appendices attached to the main text and in separate volume.

Chapter II

The Model for the Impact Study

An Input-Output model is widely used for an impact study in which an economic projection and structural relationships among disaggregated industrial sectors are to be pursued. Since the publication of the input-output analysis by Professor Leontief in 1936 the development of interindustry economic analysis in both theory and empirical application is significant. For recent developments in the I/O field see the annual proceedings of the International Conference on Input-Output Techniques at Geneva and other empirical applications.[1]

There are several alternative I/O models: national, regional, interregional, and international I/O models. Depending upon the extent of impact to be measured, the model can also be classified into open and closed categories. While an open model provides only the direct and indirect impact of a given investment, with a closed model one can extend the measurement of the impact which is induced by the increase in consumption expenditures resulting from the increase in an output. For a theoretical exposition of various alternative I/O models refer to any standard textbook dealing with Input-Output studies.[2]

As has been described in the previous chapter, the aim of the impact study of the MKARMPP is to measure the construction impact of the investment in terms of interindustry and interregional relationships. The model for the impact study which is adopted here, is the closed interregional I/O model with fixed colum coefficients. For the detailed reasons on which the model for this impact study is adopted see the previous research reports.[3] In this chapter a brief description of the interregional I/O model with a fixed column coefficient variety and its operation for the solution in general is described first, and some of the specific characteristics of the model unique to this impact study will follow.

---

[1] Philip Bourque and Millicent Cox, An Inventory of Regional Input-Output Studies in the United States. Seattle: Graduate School of Business Administration University of Wisconsin, 1970.

[2] Hollis B. Chenery and Paul G. Clark, Interindustry Economics, New York: John Wiley & Sons, Inc., 1967 and William H. Miernyk, The Elements of Input-Output Analysis, New York: Random House, 1965.

[3] Ungsoo Kim, "Research Report for Evaluation of Interregional Input-Output Models for Potential Use in the McClellan-Kerr Arkansas River Multiple Purpose Project Impact Study." Contract No. DACW 31-72-C-0059, Phase I & II, Submitted to IWR, U.S. Army Corps of Engineers, 1972.

An Interregional I/O Model with Fixed Column Coefficients

In an interregional I/O model, two sets of structural relationships, inter-industrial and interregional, are considered in combination. Industries are related by input-output activities, on the one hand, and regions are related by trades. Economic activities are analyzed in terms of both input-output among industries and trades among regions. Structural patterns (coefficients of these structural relationships) are, in Isard's notation, expressed as a_{ij}^{rs}, where the amount of commodity i from region r is required to produce one dollar's worth of output in region s.[4] Such two dimensional information, however, is not readily available. Or it may be available at the expense of unrealistic time and cost. The fixed column coefficient variety of an interregional I/O model was developed first by Chenery and Moses.[5] In this model, the interregional I/O coefficient (a_{ij}^{rs}) is estimated by two separate coefficients: i.e., regional technical coefficient (a_{ij}^{s}) and trade coefficient (t_i^{rs}). a_{ij}^{s} represents the i^{th} input required for producing one dollar's worth of j^{th} commodity in region s disregarding the region of its origin. t_i^{rs} represents the fixed proportion of total receipts (consumption) of the i^{th} commodity by region s from region r. The trade coefficients are derived by ratios of a regions' purchase of a commodity from various regions including its own, and are derived from the base year trade flow estimates. Thus the sum of the coefficients equals one.

However, the above trade pattern does not specify the interindustry relationships between trading regions. It is assumed that each purchasing industry in region s purchases the same proportion of the i^{th} input from the region r. Thus, in the fixed column coefficient model $a_{ij}^{rs} = a_{ij}^{s} \cdot t_i^{rs}$.

Having estimated the above two structural coefficients, a_{ij}^{s} and t_i^{rs}, the solution of the interregional I/O model is obtained by the following equation, $X = (I-TA)^{-1}\ TY$. The following section will briefly explain some of the theoretical and operational aspects of this model in terms of matrices.

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[4] Walter Isard, "Interregional and Regional Input-Output Analysis: A Model of a Space-Economy," Review of Economic Statistics, XXXIII (November 1951).

[5] H.B. Chenery, "Interregional Analysis," in Interindustry Economics by Chenery and Clark, New York. John Wiley & Sons, Inc., 1967, Ch. 12, pp. 308-332; and L. Moses, "The Stability of Interregional Trading Patterns and Input-Output Analysis," AER, XLV (December 1955).

Notation

The following notation will be helpful in our operational explanation of the model.

(a) Designation notation

n = designation of the number of regions.

m = designation of the number of industries.

(b) Matrix notation

X = Column vector (mn, 1) giving production. Each element describes the output of commodity i produced in region r.

Y = Column vector (mn, 1) giving total final demand. Each element describes the total amount of commodity i consumed by final users in region r regardless of the place where the good was produced.

A = Block diagonal matrix (mn,mn) with n square matrices (m,m) of input coefficients along the diagonal describing the structure of production in each region.

T = Square matrix (nm,nm) filled with diagonal matrices (m,m). Each element t_i^{rs} describes the fraction of total consumption of commodity i in region s that is imported from region r. The sum of each column of this matrix must equal to unity, since the coefficients are proportions of the total consumption. It is assumed that

$$t_i^{rs} = t_{i1}^{rs} = t_{i2}^{rs} = \ldots = t_{im}^{rs} .$$

The above matrix notations are also expressed as follows:

$$\underset{(nm,nm)}{A =} \begin{bmatrix} A^1 & & & \bigcirc \\ & A^2 & & \\ & & A^s & \\ \bigcirc & & & A^n \end{bmatrix} \qquad \underset{(m,m)}{\text{Where } A^s =} \begin{bmatrix} a_{11}^s & a_{12}^s & \cdots & a_{1m}^s \\ a_{21}^s & a_{22}^s & \cdots & a_{2m}^s \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1}^s & a_{m2}^s & \cdots & a_{mm}^s \end{bmatrix}$$

$$\underset{(nm,nm)}{T =} \begin{bmatrix} T^{11} & T^{12} & T^{1n} \\ T^{21} & T^{22} \cdots & T^{2n} \\ \vdots & \vdots \quad T^{rk} & \vdots \\ T^{n1} & T^{n2} \cdots & T^{nm} \end{bmatrix} \qquad \text{Where } T^{rk} = \begin{bmatrix} t_1^{rs} & & & \bigcirc \\ & t_2^{rs} & & \\ & & \ddots & \\ \bigcirc & & & t_m^{rs} \end{bmatrix}$$

$$X_{(nm,1)} = \begin{bmatrix} X^{10} \\ X^{20} \\ \vdots \\ X^{k0} \\ \vdots \\ X^{n0} \end{bmatrix} \quad \text{where} \quad X^{ko}_{(m,1)} = \begin{bmatrix} x_1^{so} \\ x_2^{so} \\ \vdots \\ x_m^{so} \end{bmatrix} \quad Y_{(nm,1)} = \begin{bmatrix} Y^1 \\ Y^2 \\ \vdots \\ Y^s \\ \vdots \\ Y^n \end{bmatrix} \quad \text{where} \quad Y^2 = \begin{bmatrix} Y_1^s \\ Y_2^s \\ \vdots \\ Y_m^s \end{bmatrix}$$

(d) Element notation

x_i^{ro} = the total amount of commodity i produced in region r.

x_i^{os} = the total amount of commodity i demanded by all final and intermediate consumers in region s.

x_i^{oo} = the total amount of commodity i produced (consumed) in all regions.

t_i^{rs} = a trade coefficient which is the proportion of the total consumption of commodity in region s that is shipped from region r to region s.

The Structural Relationships and Operation of the Model

The structure of production specified by A and the structure of interregional trade specified by T are essential for the column coefficient model. The relationships of economic activities among industries and regions are specified by the following sets of equations:

$$(1) \quad x_i^{or} = \sum_{j=1}^{m} a_{ij}^r x_j^{ro} + y_i^r,$$

$$(2) \quad x_i^{rs} = t_i^{rs} x_i^{os},$$

$$(3) \quad x_i^{ro} = \sum_{s=1}^{n} x_i^{rs}, \text{ and}$$

$$(4) \quad x_i^{os} = \sum_{r=1}^{n} x_i^{rs}$$

where i = 1, 2...m and r, s = 1, 2...n.

These basic economic relationships are interpreted as follows: the first equation shows the total amount of a commodity demanded and supplied in a region. The total amount of commodity i demanded by the intermediate and final users in a region must be equal to the total amount of the commodity supplied to the region. The second equation shows the total amount of commodities traded among regions. The total amount of commodity i shipped from region r to region s is a fixed proportion of the total amount of commodity i purchased by region s. The third equation simply defines the total production of commodity i in region r while the fourth is the total consumption of the commodity in region s.

Based on the functional relationships of economic activities among industries as well as regions, one can present the column coefficient model in matrix form using the matrix notations previously given. The model is written as:

$$(5) \quad X^{os} = A^{s}X^{so} + Y^{s}$$

$$(6) \quad \sum_{s=1}^{n} X^{os} = \sum_{s=1}^{n} T^{rs}X^{os}$$

$$(7) \quad \sum_{s=1}^{n} X^{os} = \sum_{s=1}^{n} X^{so}$$

where s = 1, 2...n and r = 1, 2...n.

In equation (5), for each region the total amount of commodities demanded is equal to the total amount of commodities supplied. This form of relationship is always used in the interregional input-output models. Equation (6) shows that for each region the total amount of commodities shipped equals the total amount of commodities produced. Thus, for each region the total amount of commodities shipped is the sum of the fixed proportions (including own region's) of the total production. Finally the balance of the total production and the total consumption is maintained as shown in equation (7).

Now, combining equations (5) and (6) the result shows a production equation in terms of interregional interindustry activities as follows:

$$(8) \quad \sum_{s=1}^{n} X^{so} = \sum_{s=1}^{n} T^{rs}A^{s}X^{so} + \sum_{s=1}^{n} T^{rs}Y^{s},$$

where r, s=1, 2...n.

Transferring the first term on the right hand side to the left, the following equation is obtained:

$$(9)\quad \sum_{s=1}^{1} (I - T^{rs}A^{s})\, X^{so} = \sum_{s=1}^{n} T^{rs}Y^{s}.$$

Equation (9) is written in a general form in the set of mn unknowns and mn equations as follows:

$$(10)\quad (I-TA)X = TY$$

If the technical coefficients (A), trade coefficients (T) and final demands (Y) are given, equation (10) can be solved for X as follows:

$$(11)\quad X = (I-TA)^{-1}TY;\ \text{or}\ X = (T^{-1}-A)^{-1}Y$$

In order to deliver one dollar's worth of an industry's output to the final demand in one region, the output is directly and indirectly required from the industry in another region.

Dimensions of the I/O Model for MKARMPP

For the application of the above fixed column coefficient interregional I/O model in the impact study of MKARMPP (IRIO) the model was built with four internal regions closed within the national boundaries. The impact region is the Arkansas River Valley which consists of OBE economic areas of 117, 118, and 119: parts of the states of Arkansas and Oklahoma. The impact region (Region I) is the project region, where the major construction impact of the project is expected to fall. The Southern Region (Region II) consists of the states of Texas and Louisiana and the rest of Arkansas and Oklahoma after deducting the Impact Region. The Northern Region (Region III) consists of the states of Kansas and Missouri, and the fourth region is the Rest of the United States. The division of the region is aimed at tracing the economic impact of the project according to the existing major trade patterns of the impact region with other regions. The regional boundaries are shown in Map 1.

Each region of this model has 83 industrial sectors, 79 sectors being producing sectors. Table 1 shows the classification of industries by I/O sector. The 79 producing sectors are also aggregated into 10 major producing sectors. The classification of industry sectors is based on the availability of the original data set which will be discussed in the following chapter. For a more detailed discussion of the division of the internal region and the industrial sector refer to the previous research report.[6]

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6 op. cit., Ungsoo Kim

Map 1
Regional Organization for the IRIO

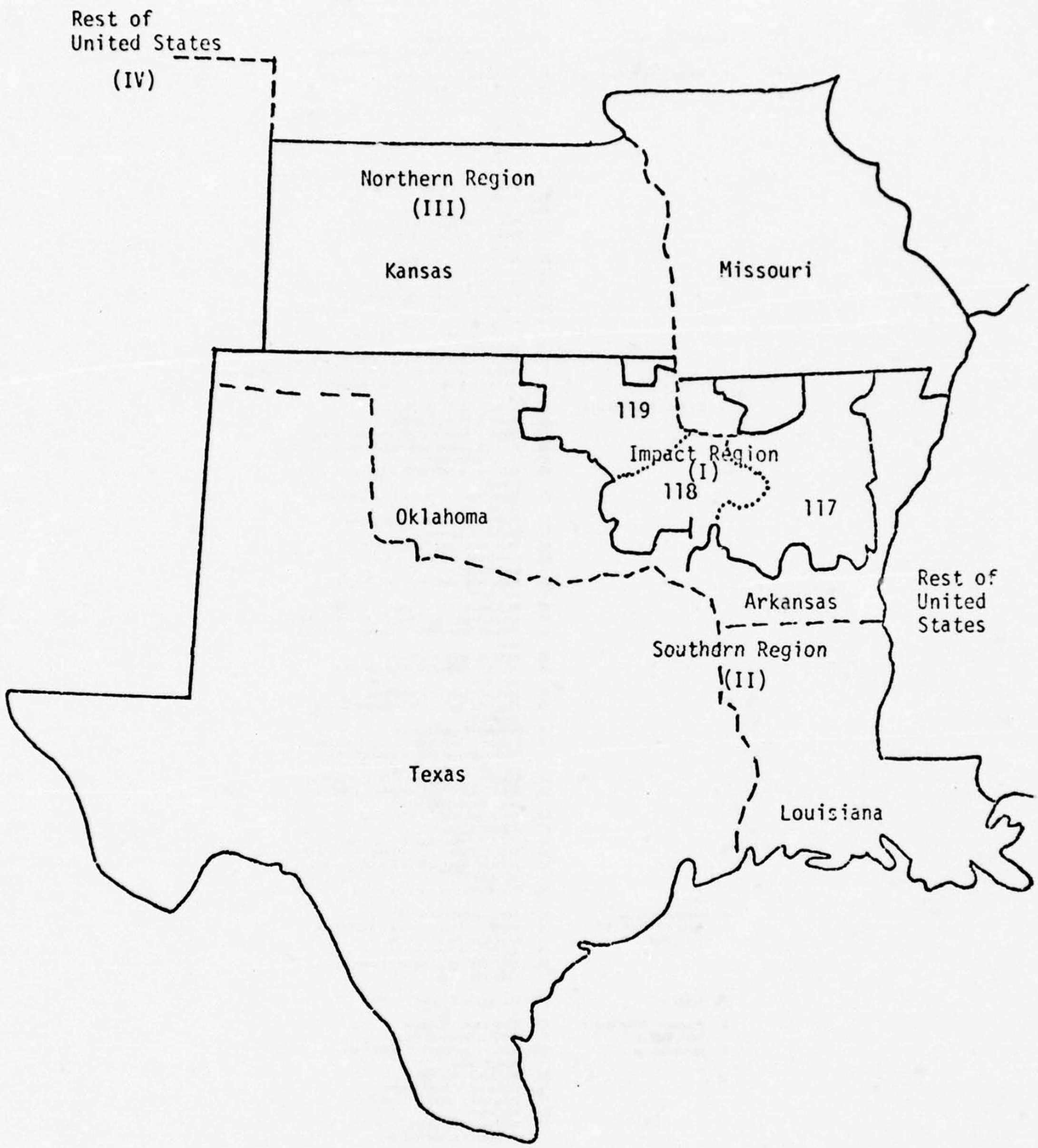

Table 1
Classification of I/O Sectors and Aggregated Industries

Aggregated Industries	I/O Industries
1. Agriculture, Forestry & Fisheries	1. Livestock & livestock products
	2. Other agricultural products
	3. Forestry & fishery
	4. Agricultural, forestry & fishery services
2. Mining	5. Iron & ferroalloy ores mining
	6. Nonferrous metal ores mining
	7. Coal mining
	8. Crude petroleum & natural gas
	9. Stone & clay mining & quarrying
	10. Chemical & fertilizer mineral mining
3. Construction	11. New construction
	12. Maintenance & repair construction
4. Nondurable Manufacturing	13. Ordnance & accessories
	14. Food & kindred products
	15. Tobacco manufactures
	16. Broad & narrow fabrics, yarn & thread mill
	17. Miscellaneous textile goods & floor coverings
	18. Apparel
	19. Miscellaneous fabricated textile products
	20. Lumber & wood products except containers
	21. Wooden containers
	22. Household furniture
	23. Other furniture and fixtures
	24. Paper & allied products except containers
	25. Paperboard containers & boxes
	26. Printing & publishing
	27. Chemicals & selected chemical products
	28. Plastics & synthetic materials
	29. Drugs, cleaning & toilet preparations
	30. Paints & allied products
	31. Petroleum refining & related industries
	32. Rubber & miscellaneous plastic products
	33. Leather tanning & industrial leather products
	34. Footwear & other leather products
5. Durable Manufacturing	35. Glass & glass products
	36. Stone & clay products
	37. Primary iron & steel manufacturing
	38. Primary nonferrous metals manufacturing
	39. Metal containers
	40. Heating, plumbing & structural metal products
	41. Stampings, screw machine products & bolts
	42. Other fabricated metal products
	43. Engine & turbines
	44. Farm machinery & equipment
	45. Construction, mining & oil field machinery
	46. Materials handling machinery & equipment
	47. Metalworking machinery & equipment
	48. Special industry machinery & equipment
	49. General industrial machinery & equipment
	50. Machine shop products
	51. Office, computing & accounting machines
	52. Service industry machines
	53. Electric industrial equipment & apparatus
	54. Household appliances
	55. Electric lighting & wiring equipment
	56. Radio, television & communication equipment
	57. Electronic components & accessories
	58. Misc. electrical machinery, equipment & supplies
	59. Motor vehicles & equipment
	60. Aircraft & parts
	61. Other transportation equipment
	62. Scientific & controlling instrument
	63. Optical, ophthalmic & photographic equipment
	64. Miscellaneous manufacturing
6. Transportation, Communications & Utilities	65. Transportation & warehousing
	66. Communications, except radio & TV broadcasting
	67. Radio & TV broadcasting
	68. Electric, gas, water & sanitary services
7. Trade	69. Wholesale & retail trade
8. Finance, Insurance & Real Estate	70. Finance & insurance
	71. Real estate and rental
9. Services	72. Hotels; personal & repair services, except auto
	73. Business services
	74. Research & development
	75. Automobile repair & services
	76. Amusements
	77. Medical, educational services & nonprofit organization
10. Government Enterprises	78. Federal government enterprises
	79. State & local government enterprises
11. Directly Allocated Imports	80. Directly allocated imports
12. Transferred Imports	81. Transferred imports
13. Value Added (Row) Final Demand (Column)	82. Value added (row) Final demand (column)
14. Secondary Products	83. Secondary products

The model is also a closed I/O model in which the household column and row coefficients are estimated and closed in the model in order to estimate income multiplier effects resulting from the induced household expenditures from the project construction.

Chapter III

Primary Data Input

The primary data sets of input for the IRIO model are: regional technical coefficients (A), trade coefficients among regions (T), the pattern of household income and consumption by each industrial sector (H), and the pattern of final demands (Y). Direct input requirements for the production of a dollar's worth of output by a purchasing industry in a region from various supplying industries and their regions of origin are available by reading the direct coefficient table in Volume II. This table is derived by the TA matrix. The direct and indirect requirements are estimated by inverting the (I-TA) matrix. Estimated household income and consumption coefficients are used to close the I/O model so that the direct and indirect, as well as, induced income impact of the investment can be evaluated. The direct, indirect induced requirement table is also available in Volume II.

Regional Technical Coefficients

As has already been mentioned in the preceding chapter, the interregional technical coefficient a_{ij}^{rs} is considered as a combination of regional technical coefficients and trade coefficients, i.e., $a_{ij}^{rs} = a_{ij}^{s} \cdot t_{i}^{rs}$. The regional technical coefficient matrices for the IRIO are estimated from the 51 states' (including Washington, D.C.) technical coefficient matrices estimated by the Harvard Research group for the Economic Development Administration, Department of Commerce.[1] The state technical coefficient in the Harvard study are estimated by the 1963 national technical coefficients weighted by the product mix pattern of each state in the same year. To estimate the A coefficient matrix for the IRIO, each states' I/O table is aggregated into four internal regions first. Because the states of Arkansas and Oklahoma are divided into the Impact Region and the Southern Region, however, each of the above two states' I/O tables are divided into two corresponding parts. The way in which the original data set in the multiregional Input-Output Model (MRIO) is manipulated for the IRIO is explained in Appendix A.[2] The technical coefficients of four regions in the IRIO for both the 79 sectors and for their aggregation into 10 sectors are shown in Volume II.

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[1] Karen R. Polenske, A Multiregional Input-Output Model for the United States, HERP Report No. 21 to EDA, Department of Commerce, 1970. For the more detailed information see supplementary report to the main report.

[2] Appendix A is a revised version of the consultant report to the IWR Army Corps of Engineers by this author in May 1973.

Trade Coefficients

The basic source of regional trade patterns is the trade flow data of 44 U.S. regions in the MRIO by the Harvard study. In the MRIO the trade flows among 44 regions[3] in the United States for 79 industrial sectors were estimated using 1963 manufacturing and transportation census and other census data for agricultural and mining industries. The estimate of trade flows in the IRIO is estimated by aggregating and disaggregating the trade flows of 44 U.S. regions into four region trade flows. The detailed procedure in estimating trade flows in the IRIO is discussed in Appendix A. The trade coefficients for IRIO by 79 industrial sectors and aggregated in 10 industrial sectors are shown in Volume II.

Regional Household Coefficients

In order to measure the induced impact of a project through an I/O model it is necessary to close the household sector in the processing matrix of an I/O model. The matrix of an inverse of direct I/O coefficients including household coefficients of an I/O model provides the direct, indirect and induced requirements of an investment dollar by each purchasing sector. While direct household row coefficients represent patterns of household incomes which are generated during the production of a dollar's output by each purchasing industrial sector, direct household column coefficients represent the household consumption pattern of a dollars worth of household income. A pattern of household earnings largely depends on the intensity of labor requirements among various inputs and their wage rate. Therefore, it depends on the production function of an industry and the local wage rate. A personal consumption pattern depends on an income distribution pattern and the taste of a region. Since our I/O model contains four internal regions, household income and spending patterns for each of these regions must be estimated.

The data of the household earnings and spending patterns for the different regions which are involved in this impact study is not available, nor is any survey practicable. The regional consumption patterns of the United States have been surveyed by the Department of Labor for the year 1960-61.[4]

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[3] Trade flows among 51 states in the United States based on 1963 trade estimates were also estimated by the same research group after this study had been initiated. The new estimate is basically the same data in the 44 region trade flows except the region containing more than one state is disaggregated into separate state.

[4] In this survey, the consumers are classified into 32 groups: rural and urban populations by various income classes. For further detailed information see, U.S. Bureau of Labor Statistics, Survey of Consumer Expenditures, 1960-61. Washington, D.C.: U.S. Government Printing Office, 1966.

This survey has been conducted over four U.S. Census regions. But the regional boundaries for this survey are different from those which are used in our model. However, this survey is utilized in estimating state consumption expenditures by industry sector in the MRIO by Polenske et al.[5] We have found that the aggregation of each state's consumption expenditure in the MRIO into IRIO regions is the most appropriate data in estimating the consumption patterns of IRIO regions without a survey. The division of consumption expenditures of the states of Arkansas and Oklahoma into substates due to the division of these states into substates within and outside of the Impact Region are based on the share of each state's personal income by each substate. The estimated regional consumption patterns of IRIO regions for the 80 industrial sector in terms of coefficients are shown in Table 2. These coefficients show the marginal propensity to consume by the I/O sector.

In estimating household row coefficients the share of value-added which is attributable to personal income by industry and by region is first estimated. The share of value-added by each industry and by the IRIO region is available from the I/O table of the IRIO. The share of personal income before tax, generated by industry, is estimated by summing the proportion of value-added which is attributable to wages and salaries, other types of labor income, and incomes from property by industry. The national shares of these types of income out of value-added by industry are available from the unpublished data by the Department of Commerce. The household income coefficients by industry and region, therefore, can be estimated by multiplying the value-added coefficient of each region by industry by the household income share of value-added of each national industry. In order to close the household sector into the processing matrix the sum of household rows and columns must be made equal. However, the personal income is larger than the consumption expenditures due to the inclusion of the personal income tax and personal savings.[6] Therefore, the household income coefficients are reduced by multiplying the ratio of the total household spending to the total household income of each region. The ratio of the total household income to the total consumption of a region is the average propensity to consume of each region. The household earning pattern for the consumption (household row coefficients) for each of the 80 industrial sectors is also shown in Table 2.

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[5] In this estimate the state population is subdivided into rural and urban residence and those are further divided into 16 income groups. The state consumer expenditures for these classifications are distributed among each industrial sector based on the consumer expenditure patterns of the same classification of those census regions where each state belongs. For the detailed methodology see Polenske, Karen R. and Isabella B. Whiston, State Estimates of Personal Consumption Expenditures 1947, 1958, 1963. EDA Report No. 14 (Harvard Economic Research Project), August 1968.

[6] It is implicitly assumed that the transfer payment is less than the personal income tax and savings.

Table 2
Coefficients of Household Column and Row

I/O	Column				Row			
#	Region I	Region II	Region III	Region IV	Region I	Region II	Region III	Region IV
1	0.005508	0.005188	0.005010	0.004632	0.211664	0.185709	0.134091	0.147737
2	0.008482	0.007677	0.008051	0.007608	0.379077	0.297771	0.261945	0.334910
3	0.001087	0.001073	0.001113	0.001121	0.333804	0.225303	0.111793	0.253574
4	0.000025	0.000020	0.000026	0.000043	0.301954	0.269015	0.219659	0.228539
5	0	0	0	0	0.386920	0.134531	0.190465	0.236915
6	0	0	0	0	0.325837	0.020175	0.299020	0.310879
7	0.000478	0.000389	0.000638	0.000435	0.584982	0.530409	0.610347	0.426566
8	0	0	0	0	0.396186	0.352548	0.373322	0.260875
9	0.000039	0.000041	0.000040	0.000039	0.422063	0.310377	0.419612	0.391541
10	0.000004	0.000004	0.000005	0.000005	0.269827	0.477599	0.314888	0.324011
11	0	0	0	0	0.357858	0.257510	0.339855	0.328338
12	0	0	0	0	0.493931	0.441986	0.461193	0.458652
13	0.000423	0.000459	0.000455	0.000486	0.002334	0.221714	0.325707	0.320410
14	0.130895	0.127640	0.132550	0.133400	0.160490	0.158552	0.164545	0.176909
15	0.014901	0.014162	0.013028	0.013067	0	0.135020	0.196558	0.152647
16	0.002009	0.001946	0.001596	0.001655	0.218903	0.188281	0.197529	0.208810
17	0.002041	0.002333	0.002773	0.002724	0.176034	0.047224	0.205040	0.159408
18	0.035742	0.036462	0.036139	0.036492	0.349877	0.313596	0.326726	0.322871
19	0.004077	0.004150	0.003755	0.003936	0.157115	0.220580	0.246555	0.201233
20	0.001205	0.000734	0.000568	0.000601	0.336431	0.287854	0.281878	0.281490
21	0	0	0	0	0.300597	0.259494	0.286126	0.267494
22	0.008490	0.008673	0.008075	0.007999	0.365180	0.322422	0.332519	0.334211
23	0.000376	0.000370	0.000367	0.000351	0.339271	0.325201	0.365953	0.356464
24	0.003729	0.003655	0.003149	0.003278	0.359383	0.312514	0.283148	0.288728
25	0.000206	0.000211	0.000174	0.000196	0.321830	0.284065	0.301948	0.295961
26	0.007675	0.007966	0.008575	0.008452	0.455097	0.413071	0.410577	0.394476
27	0.001211	0.001147	0.001072	0.001040	0.170601	0.317476	0.300711	0.300144
28	0.000035	0.000034	0.000032	0.000033	0.092807	0.265311	0.165048	0.305975
29	0.017264	0.016522	0.014094	0.014271	0.118663	0.169906	0.299258	0.311135
30	0.000058	0.000058	0.000063	0.000061	0.285022	0.244234	0.276664	0.271934
31	0.022732	0.021403	0.023409	0.028972	0.070706	0.062982	0.066931	0.062816
32	0.005457	0.005415	0.004811	0.004926	0.356768	0.028440	0.322145	0.318465
33	0	0	0	0	0	0.186287	0.220996	0.213146
34	0.008356	0.008212	0.008313	0.008050	0.422268	0.366265	0.387377	0.371193
35	0.000318	0.000631	0.000612	0.000636	0.476429	0.405719	0.439894	0.426780
36	0.000589	0.000570	0.000587	0.000577	0.406321	0.348862	0.394419	0.372309
37	0.000027	0.000024	0.000034	0.000025	0.370813	0.255065	0.363260	0.336530
38	0.000036	0.000036	0.000029	0.000033	0.269658	0.224273	0.254035	0.234307
39	0	0	0	0	0.296546	0.266849	0.279128	0.274343
40	0.000312	0.000273	0.000230	0.000231	0.345138	0.304836	0.314600	0.301930
41	0.000734	0.000723	0.000667	0.000708	0.358345	0.264493	0.312353	0.361361
42	0.001674	0.001653	0.001543	0.001534	0.380346	0.310799	0.367705	0.338216
43	0.000357	0.000400	0.000236	0.000330	0.007763	0.184754	0.220385	0.314791
44	0.000031	0.000029	0.000029	0.000028	0.272905	0.215053	0.281619	0.265397
45	0	0	0	0	0.401722	0.368834	0.291319	0.306112
46	0	0	0	0	0.238706	0.235931	0.306209	0.298300
47	0.000213	0.000212	0.000214	0.000205	0.275151	0.246932	0.356514	0.395875
48	0.000057	0.000057	0.000057	0.000055	0.292120	0.296333	0.340490	0.334205
49	0	0	0	0	0.392452	0.310269	0.322211	0.360790
50	0.000006	0.000006	0.000005	0.000005	0.419784	0.392927	0.420498	0.400060
51	0.000243	0.000243	0.000241	0.000232	0.409597	0.237722	0.376071	0.415751
52	0.001602	0.001834	0.000799	0.000816	0.219749	0.274138	0.287625	0.254999
53	0.000060	0.000059	0.000060	0.000057	0.399213	0.320948	0.387955	0.373094
54	0.008893	0.008221	0.007364	0.007361	0.305822	0.198638	0.221811	0.261666
55	0.001172	0.001164	0.001153	0.001117	0.371257	0.259965	0.353006	0.336094
56	0.005369	0.005535	0.005827	0.005556	0.324576	0.368798	0.381960	0.382526
57	0.000453	0.000467	0.000493	0.000468	0.054331	0.320383	0.291306	0.382087
58	0.001072	0.001074	0.000949	0.000973	0.113042	0.326359	0.349237	0.349538
59	0.041899	0.042395	0.043794	0.040718	0.206548	0.199264	0.214964	0.210797
60	0.000141	0.000158	0.000093	0.000130	0.431639	0.379515	0.400880	0.381948
61	0.002810	0.003143	0.001860	0.002593	0.289142	0.348161	0.246105	0.298926
62	0.001132	0.001167	0.001053	0.001064	0.330640	0.306213	0.311537	0.352024
63	0.001481	0.001509	0.001692	0.001613	0.059403	0.279676	0.415878	0.455617
64	0.008517	0.008794	0.008632	0.008878	0.368897	0.284834	0.327630	0.325357
65	0.020780	0.021417	0.022248	0.024101	0.477871	0.403102	0.441299	0.412330
66	0.013928	0.014340	0.014568	0.014808	0.566058	0.506577	0.528567	0.525636
67	0	0	0	0	0.478429	0.428018	0.446646	0.444132
68	0.034383	0.033263	0.033893	0.029816	0.260344	0.223775	0.271388	0.255329
69	0.219974	0.215251	0.217521	0.214981	0.543340	0.484454	0.503633	0.499925
70	0.042669	0.044602	0.044473	0.045017	0.304674	0.263305	0.282784	0.278627
71	0.125366	0.130803	0.142289	0.144733	0.239701	0.215061	0.231721	0.236498
72	0.033267	0.034151	0.029538	0.032079	0.399066	0.357081	0.372580	0.370554
73	0.007610	0.007376	0.009087	0.007900	0.408239	0.394046	0.363768	0.379240
74	0	0	0	0	0	0	0	0
75	0.020140	0.019940	0.017102	0.017654	0.412220	0.367943	0.384952	0.380731
76	0.010536	0.011015	0.011288	0.012742	0.308047	0.275847	0.287798	0.286752
77	0.080398	0.081698	0.076989	0.077845	0.642439	0.574852	0.599837	0.596532
78	0.002184	0.002221	0.002353	0.002379	0.692457	0.619663	0.646578	0.631854
79	0.001942	0.001955	0.001632	0.001679	0.566692	0.507093	0.529129	0.526201
80	0.011990	0.014304	0.007837	0.011511	0.011990	0.014304	0.007837	0.011511

Construction of Final Demand Vectors

In order to utilize an interregional I/O model for an impact study, a final demand vector, which is an exogeneous variable to the I/O model, must be estimated. The final demand may be an increase in investment, consumption, public expenditures or exports. The purpose of this study is to evaluate the construction impact of the McClellan-Kerr Arkansas River Multiple Purpose Project (MKARMPP). Therefore, the final demand for this project will be the total construction expenditures. And the final demand vector will be the purchase pattern of the project construction expenditures from various industrial sectors.

The precise figure of the total project cost for the MKARMPP is difficult to decide. The history of water resource development investments in the Arkansas River Basin had its origin in the late 1930's, and many water resource investments in this area have contributed to this project.[7] The total project cost for the MKARMPP varies according to different references. In this study the federal expenditures appropriated during FY 1957 to 1971 are treated as the MKARMPP costs. These expenditures were responsible for opening the waterway from the junction of the Arkansas and Mississippi Rivers to the Tulsa area in Oklahoma and are estimated in the Washington University study.[8] The total expenditures through FY 1957-1971 by types of project are estimated at approximately 1.2 billion current dollars and are shown in Table 3.

Procedures in Estimating Final Demand Vectors for a Project Contract Cost

The following procedures are followed to estimate the final demand vectors for the proposed interregional I/O model (IRIO) and in evaluating the construction impact of the MKARMPP on local and national economies:

Step 1: Estimation of Construction Costs in 1963 Dollars

Since the IRIO is based on 1963 data, it is preferable to express the final demand for this model in terms of 1963 prices. The estimated total project cost in 1963 prices is approximately 1.1 billion dollars, and the detail distribution of the cost by project type and year is shown in parentheses in Table 3.

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[7] Institute for Water Resources, U.S. Army Corps of Engineers. A River, A Region, and A Research Problem, IWR Report 71-6, by Charles L. Leven and R. B. Read, Washington University, July 1971, Part II, pp. 18-40.

[8] Ibid., Appendix C.

Table 3 Appropriation History
Arkansas River and Tributaries
(in Thousands $)

Projects	Alloc Thru FY 57	FY 58	FY 59	FY 60	FY 61	FY 62	FY 63	FY 64	FY 65	FY 66	FY 67	FY 68	FY 68	FY 69	FY 70	FY 71	Total
Keystone	2,219	1,875	6,990	9,524	20,939	28,190	20,290	12,344	6,390	5,600	4,395	3,278	3,278	1,553	0	0	122,547
	(2,276)	(1,845)	(7,374)	(9,836)	(20,591)	(28,555)		(12,159)	(6,002)	(5,270)	(4,006)	(2,875)	(2,875)	(1,298)			(122,520)
Eufaula	2,585	2,735	6,450	7,900	20,261	29,458	29,922	17,275	4,076	106	109	214	214	0	25	0	121,237
	(2,754)	(2,691)	(6,605)	(8,200)	(20,768)	(29,671)		(17,016)	(3,941)	(100)	(91)	(158)	(158)		(25)		[illegible]
Webbers Falls	0	0	0	0	0	74	302	416	2,875	6,125	10,000	12,765	12,765	12,500	9,350	11,579	[illegible]
						(75)		(403)	(2,750)	(5,744)	(9,667)	(11,135)	[illegible]	(10,701)	(7,890)	(8,765)	[illegible]
R. S. Kerr	0	0	0	0	0	406	475	2,645	10,651	18,100	20,700	12,671	12,671	11,299	9,157	[illegible]	[illegible]
						(411)		(2,605)	(10,300)	(17,032)	(18,878)	(11,112)	(11,112)	(9,371)	(7,262)	(4,531)	[illegible]
Ozark	0	0	0	0	0	298	300	313	1,150	9,925	11,710	11,570	11,570	10,285	9,200	11,758	[illegible]
						(302)		(308)	(1,112)	(9,339)	(10,680)	(10,147)	(10,147)	[illegible]	[illegible]	(8,952)	[illegible]
Dardanelle	1,225	819	1,188	4,978	6,215	7,877	10,230	21,341	9,931	1,950	475	3,325	3,325	8,316	[illegible]	[illegible]	[illegible]
	(1,256)	(806)	(1,253)	(5,063)	(6,370)	(7,779)		(21,021)	(9,603)	(1,835)	(433)	(3,355)	(3,355)	(6,701)	[illegible]	(597)	[illegible]
Oologah	4,666	4,800	9,100	11,045	3,423	1,587	1,195	525	260	73	559	572	872	3,120	3,375	267	[illegible]
	(4,736)	(4,724)	(9,601)	(11,465)	(3,514)	(1,636)		(517)	(251)	(69)	(502)	(765)	(765)	(2,605)	2,676	(232)	[illegible]
Bank Stabilization	23,495	1,533	2,542	4,817	5,864	17,880	19,677	14,495	12,271	8,000	4,925	2,800	2,800	3,335	3,559	1,035	[illegible]
	(24,037)	(1,506)	(2,682)	(5,000)	(6,011)	(19,112)		(14,278)	(11,866)	(7,528)	(4,492)	(2,456)	(2,456)	(2,838)	(2,615)	(761)	[illegible]
Navigation Locks	79	0	0	0	0	2,307	2,326	9,600	49,639	73,500	85,037	77,457	77,457	71,300	55,954	28,257	[illegible]
	(80)					(2,935)		(9,535)	(48,000)	(69,164)	(77,554)	(67,940)	(67,940)	(59,607)	(44,372)	(21,391)	[illegible]
Navigation Aids (U.S. Coast Guard)	0	0	0	0	0	0	0	0	0	0	1,000	1,150	1,150	118	0	0	2,268
											(912)	(1,002)	(1,002)	(99)			[illegible]
TOTAL	39,368	11,759	26,270	38,164	55,357	98,637	84,717	79,114	97,153	123,379	139,492	126,614	126,614	121,796	95,541	57,472	1,182,333
	(35,249)	(11,572)	(27,715)	(39,614)	(57,254)	(87,549)	(84,717)	(77,928)	(93,945)	(116,101)	(127,217)	(111,042)	(111,042)	(101,821)	(75,765)	(45,020)	(1,054,209)

Footnote:
(1) Source: Institute for Water Resources. A River, a Region and a Research Problem, IWR Report 71-6, Appendix C. Table C-1.
(2) This budget is estimated to be project costs of McClellan-Kerr Arkansas Multiple Purpose Project.
(3) Appropriation figures without bracket under each year indicate project costs in current year prices and figure in bracket is in 1963 constant dollars. The 1963 constant dollars are derived by unpublished GNP deflators from the BEA, Department of Commerce.

Total project cost includes construction contract costs which are executed through private contract and non-contract costs which were expended directly by the Army District Corps of Engineers. Non-contract costs include expenditures such as compensation for land and damages; engineering and design; and supervision and administration of the projects. The proportion of contract and non-contract costs by type of project, are shown in Table 4. The contract cost of the whole MKARMPP occupy approximately 80 percent of the total project cost, which is equivalent to $878,298,000 in 1963 prices.

Step 2: Distribution of Project Costs by Sectoral Demand

In order to use the I/O model with 83 industrial sectors, the investment expenditures must be distributed by 83 sectors. The actual distribution of project expenditures by industrial sectors is a major task, which requires records of all expenditures spent for purchasing goods and services for the construction of the project by the Army Corps of Engineers and private contractors. However, a study of distribution patterns of contract costs for 12 different types of water resource projects by 83 industrial sectors is available from the unpublished study by The Resource For The Future, Inc. This study is an extension of Bulletin No. 1390, by the Bureau of Labor Statistics. In this Bulletin, the BLS made available sample surveys of 45 water resource investment projects[9] by the Army Corps of Engineers in order to generalize labor and material requirement patterns. In this study Haveman and Krutilla added an investigation of three more projects and have developed a detailed purchase pattern of equipment and supplies by major industrial sectors; purchase patterns of on-site labor[10] by major occupations; and unallocated costs per $1,000 contract costs for 12 different project categories.[11] The classification of project types and sample projects, which were surveyed under each project category, are shown in Appendix B. The purchase patterns developed by Haveman and Krutilla were based on 1958 prices. To convert 1958 purchase patterns into those of 1963, sectoral GNP deflators were used.[12] The estimated

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[9] The 45 water resource projects involve 235 major civil works contracts.

[10] On-site labor is defined as the demand for labor for the project construction at the site of the project. This is the major portion of wage and salaries paid out from project expenditures.

[11] Robert H. Haveman and John V. Krutilla. Unemployment, Idle Capacity, and the Evaluation of Public Expenditures: National & Regional Analysis. Baltimore: The Johns Hopkins Press, 1968, Table 6, pp. 20-21. Distribution of equipment and supply requirements by 1958 I/O sectors are also available from unpublished data.

[12] For the deflation of project costs and sectoral demands, unpublished GNP and sectoral deflators from the Bureau of Economic Analysis, Department of Commerce, were used.

Table 4

McClellan-Kerr Arkansas River Multiple Purpose Project Costs
by Project Type, Contract and Non-Contract Costs
(in thousands 1963 dollars)

Project Title	Project Classification	Project Cost	Contract Cost	Non-Contract Cost***
Keystone	Multiplt Purpose incl. powerhouse	122,520	91,253 (.7448)	31,267 (.2552)*
Eufoula	"	122,367	86,991 (.7109)	35,376 (.2891)
Webbers Falls	"	57,628	46,921 (.8142)	10,707 (.1858)
R. S. Kerr	"	81,976	62,130 (.7579)	19,846 (.2421)
Ozark	"	56,945	46,706 (.8202)	10,239 (.1798)
Dardanelle	"	79,846	62,048 (.7771)	17,798 (.2229)
Total Multiple Purpose Project Cost		521,282	396,049 (.7598)	125,233 (.2402)
Oologah	Flood Control	44,483	25,257 (.5678)	19,226 (.4322)
Bank Stabilization	Revetments	124,119	106,643 (.8592)	17,476 (.1408)
NavigationLocks	Locks and Dams**	404,924	350,340 (.8652)	54,584 (.1348)
Total Project Cost		1,094,808	878,289 (.8022)	216,519 (.1978)

Sources:
Institute for Water Resources, A River, a Region and a Research Problem, IWR Report 76-6, Appendix C, Table c-1, and PB Form 1 from Tulsa District Engineers.

* Indicates proportion to each project cost.

** Navigation Locks include both Navigation Locks and Navigation Aids by the U. S. Coast Guard.

*** Non-contract cost includes direct expenditures by District Engineers for land and damage; engineering and design; and supervision and administration of the project construction. Whereas, contract costs are spent by private contractors. The proportion of land and damage; engineering and design; and supervision and administration costs to the McClellan-Kerr Multiple Purpose Prpject is 8.64%; 5.7%; and 5.12% respectively.

1963 purchase patterns per $1,000 contract costs for water resource investments, by project type and industrial sectors, are shown in Table 5. The sum of sectors 1 to 82 shows total material requirements. Sector 83 represents on-site demand for labor and unallocated costs and assumed to be the household income of a project region. The magnitude of household income indicates the intensity of direct labor requirements of a project. According to Table 5 demands for direct labor range from 19 percent (power house) to 59 percent (levees) of the total construction cost. The sum of total material requirements and household income is $1,000. As Table 4 indicates, the MKARMPP is composed of several types of projects: multiple purpose, flood control, revetment, and the locks and dams projects. The demand pattern for equipment and materials by each project type multiplied by its total project contract costs becomes the final demand vector for the particular water resource construction project. The total final demand vectors resulting from the contract construction costs of the MKARMPP are shown in Table 6.

A final demand generated by a project is not necessarily produced in a project region. Some of the project demand may be produced in non-project regions, where relative comparative advantages in supplying certain goods and services are superior to those of a project region. The demand for the goods and services which have characteristics, such as automobile repair services, may be satisfied entirely within a project region; whereas demand for automobiles will be supplied from the automobile manufacturing regions. In this study, final demands resulting from a project without considering origins of supplies are defined as "total final demand" or "national final demand." Actual demands imposed on each region for their production are defined as "regional final demands." In an interregional I/O analysis, regional final demands are the keys in measuring economic impacts of a project on various regions.

Step 3: Estimation of Regional Final Demands

The regional distribution of a total final demand for a particular project may depend upon: (1) the size and type of a project, and (2) the project location and the trade pattern of the project region with other regions for each commodity. The project type will dictate the product mix pattern of a total final demand, and the project region and its trade pattern with other regions will dictate the origins of goods and services to satisfy a total final demand required in a project region. The product mix pattern of a total final demand by project type is already estimated in Step 2. The trade patterns of a region for each of 79 goods and service sectors were already estimated in the basic I/O model (IRIO)[13] and are expressed in terms of T matrices.

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[13] See Appendix A of this report.

Table 5
NATIONAL FINAL DEMAND VECTOR PER $1000
CONTRACT COST FOR WATER RESOURCE INVESTMENT
BY PROJECT TYPE AND I/O SECTOR
(UNIT: 1963 DOLLARS)

I/O Sector	Multpl Purp. Proj. Inc. Pow.	Dredg.	Large Earth Fill Dam	Small Earth Fill Dam	Local Flood Protec.	Pile Dikes	Levees	Revet-ment	Power-house	Medium Concr. Dam	Lock & Concr. Dam	Misc.
1 Livestock & its Prod	*------	------	------	------	------	------	------	------	------	------	------	------
2 Other Agr Prod	------	------	0.16	0.81	0.25	------	0.22	------	0.02	0.05	0.87	1.00
3 Forstry & Fishry Prod	------	------	------	------	------	------	------	------	------	------	------	------
4 Agr Forstry & Fishry Svcs	------	------	------	------	------	------	------	------	------	------	------	------
5 Iron & Froally Ores Ming	------	------	------	------	------	------	------	------	------	------	------	------
6 Nonfer Mtl Ores Ming	------	------	------	------	------	------	------	------	------	------	------	------
7 Coal Ming	------	------	------	------	------	------	------	------	------	------	------	------
8 Crd Petr & Nat'l Gas	------	------	------	------	------	------	------	------	------	------	------	------
9 Stone & Clay Ming & Quary	44.88	0.01	0.26	25.81	44.52	131.07	77.07	324.07	9.38	1.71	72.07	24.59
10 Chem & Fert Min Ming	------	------	------	------	------	------	------	------	------	------	------	------
11 New Constr	------	------	------	------	------	------	------	------	------	------	------	------
12 Maint & Repr Constr	------	------	------	------	------	------	------	------	------	------	------	------
13 Ord & Acces	------	------	------	------	------	------	------	------	------	------	------	------
14 Food & Kindrd Prod	------	------	------	------	------	------	------	------	------	------	------	------
15 Tobacco Manf	------	------	------	------	------	------	------	------	------	------	------	------
16 Brd.& Nrw Fab Yrn & Thrd Mls	------	------	------	------	------	------	------	------	0.46	2.00	------	------
17 Misc Tex Gds & Flr Cov	0.15	0.79	0.21	------	0.01	------	------	------	------	0.11	------	------
18 Apparel	------	------	------	------	------	------	------	------	------	------	------	------
19 Misc. Fab Tex Prod	------	------	------	------	0.32	------	------	------	------	0.39	0.01	------
20 Lumb & Wd Prod Ex Cont	5.51	0.06	7.46	5.53	11.09	52.31	1.07	42.67	11.61	4.96	4.34	19.51
21 Wood Cont	------	------	0.02	------	------	------	------	------	------	------	------	------
22 Houshld Furn	------	------	0.02	------	------	------	------	------	0.24	------	------	------
23 Oth Furn & Fix	0.46	------	------	------	0.04	------	------	------	0.56	------	------	------
24 Pap & Allied Prod Ex Cont	0.73	------	------	------	------	------	------	------	0.14	0.01	------	------
25 Paperbd Cont & Bxs	------	------	------	------	------	------	------	------	------	0.27	------	------
26 Print & Pub	0.15	------	------	------	------	------	------	------	------	------	------	------
27 Chem & Sel Chem Prod	6.09	12.23	15.65	43.59	2.39	13.06	1.27	------	0.80	7.78	1.17	21.79
28 Plasts & Syn Mat	------	0.97	------	------	0.10	------	------	------	------	------	------	0.08
29 Drgs Cleng & Toilt Prep	------	------	0.15	------	0.52	------	------	------	------	0.59	------	0.03
30 Paints & All Prod	0.05	------	0.17	0.08	0.07	------	0.02	------	1.60	1.12	0.99	0.10
31 Pet Ref & Rel Ind	12.22	94.13	76.19	61.60	26.53	30.84	83.22	44.76	2.37	5.41	14.79	91.65
32 Rub & Misc Plastics Prod	6.17	------	0.89	6.54	6.40	3.46	9.66	2.75	1.75	1.74	3.52	10.74
33 Leathr Tan & Indust Leathr Prod	------	------	------	------	------	------	------	------	------	------	------	------
34 Ftwr & Oth Leathr Prod	------	------	------	------	------	------	------	------	------	------	0.01	------
35 Gls & Gls Prod	------	------	0.01	------	------	------	------	------	0.13	------	------	------
36 Stone & Clay Prod	57.68	------	13.51	9.39	65.71	------	0.58	0.22	13.79	90.93	115.28	51.64
37 Prim Iron & Steel Manuf	31.23	43.40	1.18	3.25	4.61	4.09	1.41	1.70	5.67	27.77	65.25	35.86
38 Prim Nonfer Met Manuf	3.25	0.67	0.46	0.23	0.31	------	0.03	1.71	7.88	4.93	1.52	------
39 Metal Cont	------	------	------	------	------	------	------	------	------	------	------	------
40 Heat Plumb & Struct Metl Prod	69.03	0.54	49.49	25.68	109.55	------	5.09	0.19	28.19	75.71	42.92	0.27
41 Stamps Screw Mach Prod & Bolts	0.15	------	------	0.17	0.09	------	------	------	1.23	------	2.47	------
42 Oth Fab Metl Prod	6.02	19.88	5.19	4.53	12.25	15.66	4.87	8.23	12.57	4.70	5.38	4.84
43 Eng & Turb	33.13	------	------	------	------	------	------	------	224.43	1.17	4.80	0.09
44 Farm Mach & Equip	------	------	0.12	0.02	------	------	0.25	------	0.16	0.08	0.05	0.01
45 Construct Ming & Oil Field Mach	44.33	31.45	103.00	150.38	40.79	59.39	70.23	19.27	25.21	83.51	109.14	106.52
46 Matls Handlg Mach & Equip	2.42	------	3.82	2.24	------	------	------	------	31.14	24.39	29.84	------
47 Mtlwork Mach & Equip	2.43	0.09	0.38	0.51	0.20	------	------	------	1.35	2.30	0.18	------
48 Spec Indust Mach & Equip	0.14	------	------	0.45	0.07	------	0.02	------	------	0.01	0.40	0.16
49 Gen Indust Mach & Equip	2.12	0.49	9.47	10.12	2.83	6.24	0.58	0.05	6.65	9.05	9.61	9.14
50 Mach Shop Prod	------	------	0.08	0.26	------	------	------	------	0.02	0.51	11.67	------
51 Ofc Comput & Acct Mach	0.80	------	------	------	------	0.55	0.06	------	------	------	0.78	0.96
52 Svc Indust Mach	2.43	------	0.60	------	------	------	------	------	0.12	8.03	------	------
53 Elect Indust Equip & App	39.62	------	1.08	0.92	0.47	------	0.20	------	262.26	2.60	5.31	------
54 Househld App	------	------	------	------	0.47	------	------	------	------	------	------	------
55 Elect Light & Wir Equip	------	0.41	0.61	0.69	0.11	------	0.02	------	2.98	------	11.34	0.23
56 Radio TV & Comm Equip	0.74	------	0.23	------	------	------	------	------	0.40	------	------	------
57 Elec Comp & Ass	------	------	------	------	------	------	------	------	------	------	------	------
58 Misc Elect Mach Equip & Sup	------	------	------	------	0.04	------	------	------	0.03	------	------	------
59 Motor Veh & Equip	3.69	1.16	72.66	71.30	20.14	8.33	8.93	4.17	3.97	15.92	11.39	46.93
60 Aircraft & Pts	------	------	------	------	------	------	------	------	------	------	------	------
61 Oth Transp Equip	1.62	146.69	------	------	0.01	37.28	12.70	15.06	0.01	3.70	9.17	0.80
62 Scient & Cont Equip	1.76	0.19	0.02	0.02	0.15	------	------	------	1.07	0.28	------	0.16
63 Opt Opth & Photo Equip	------	------	------	------	------	------	------	------	------	------	------	------
64 Misc Manuf	0.01	------	0.01	0.01	0.09	------	0.05	------	1.87	0.02	------	0.26
65 Transpt & Warehous	37.13	15.77	14.62	29.55	36.14	82.59	49.93	170.76	22.28	17.86	57.93	32.67
66 Comm Except Radio & TV Bdcst	1.97	1.94	1.96	1.96	1.96	1.94	1.93	1.92	2.04	1.97	1.97	1.95
67 Radio & TV Bdcst	------	------	------	------	------	------	------	------	------	------	------	------
68 Elec Gas Water & Sanit Svcs	2.74	2.90	2.72	2.73	2.73	2.70	2.68	2.67	1.45	16.32	1.11	1.90
69 Wholesale & Retl Trade	61.09	54.57	113.53	115.42	85.95	67.06	54.25	70.65	93.06	83.07	99.55	104.01
70 Finance & Insur	8.35	8.23	8.31	8.33	8.32	8.25	8.13	8.15	9.65	8.35	8.36	8.33
71 Real Est & Rentl	3.97	3.91	3.95	3.96	3.95	3.92	3.89	3.87	4.11	3.97	3.97	3.94
72 Hot Pers & Repr Svcs exc Auto	------	------	------	------	------	------	------	------	------	------	------	------
73 Business Svcs	------	------	------	------	------	------	------	------	------	------	------	------
74 Res & Dev	------	------	------	------	------	------	------	------	------	------	------	------
75 Auto Rep & Svcs	4.96	4.89	4.94	4.95	4.94	4.90	4.87	4.85	5.14	4.96	4.97	4.93
76 Amusements	------	------	------	------	------	------	------	------	------	------	------	------
77 Med Ed Svcs & Nonprof Organ	1.21	1.19	1.20	1.20	1.20	1.19	1.18	1.18	1.25	1.21	1.21	1.20
78 Fed Govt Enter	------	------	------	------	------	------	------	------	------	------	------	------
79 State & Local Govt Enter	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.28	0.27	0.27	0.27
80 Imports	------	------	------	------	------	------	------	------	------	------	------	------
81 Bus Travel Entertain & Gifts	4.63	4.56	4.61	4.62	4.61	4.57	4.54	4.52	4.80	4.63	4.64	4.63
82 Ofc Sup	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.24	0.24	0.24
83 Household Income**	494.23	548.30	472.52	402.65	506.76	459.30	560.63	258.06	196.61	474.52	281.86	407.69
84 Sum of sector 1-83	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0

Footnote: This table was derived by modifying the unpublished table of the spending patterns of per $1,000 contract cost of various water resource projects for the direct purchase of material and labor by the Resource for the Future Inc. The original table which is expressed in terms of 1958 dollars, was translated in terms of 1963 dollars by multiplying sector deflaters.

* ------ means insignificant, i.e. less than $0.05 or zero.

** Household income refers primarily to payment for labor. However, it also includes unallocated cost for the use of contingencies and tax or profit margin.

Table 6
National Final Demand Vectors for the McLellan-Kerr Arkansas
River Multiple Purpose Project Contract Cost
(Unit $1,000 1963 Prices)

Project Category

I/O Sector	Multiple Purpose	Flood Control	Revetments	Locks & Dams	Total Project
1	00	00	00	00	00
2	00	6.32	00	305.51	311.83
3	00	00	00	00	00
4	00	00	00	00	00
5	00	00	00	00	00
6	00	00	00	00	00
7	00	00	00	00	00
8	00	00	00	00	00
9	17774.17	1124.37	34559.73	25250.03	78708.30
10	00	00	00	00	00
11	00	00	00	00	00
12	00	00	00	00	00
13	00	00	00	00	00
14	00	00	00	00	00
15	00	00	00	00	00
16	00	00	00	00	00
17	60.69	0.24	00	00	60.93
18	00	00	00	00	00
19	00	8.12	00	3.54	11.66
20	2181.46	277.90	4550.57	1521.45	8531.37
21	00	00	00	00	00
22	00	00	00	00	00
23	180.29	1.04	00	00	181.33
24	287.93	00	00	00	287.93
25	00	00	00	00	00
26	59.42	00	00	00	59.42
27	2410.93	60.43	00	410.40	2881.76
28	00	2.53	00	00	2.53
29	00	13.10	00	00	13.10
30	21.72	1.84	00	346.27	369.83
31	4841.06	669.97	4772.91	5179.84	15463.79
32	2441.93	161.67	292.93	1231.89	4128.42
33	00	00	00	00	00
34	00	00	00	3.78	3.78
35	00	00	00	00	00
36	22843.31	1659.71	23.07	40596.13	65122.22
37	12449.01	116.36	181.79	22860.33	35607.49
38	1287.96	7.77	182.83	531.88	2010.44
39	00	00	00	00	00
40	27340.72	2766.87	20.30	15038.09	45165.99
41	57.91	2.21	00	865.06	925.20
42	2385.85	309.50	878.03	1884.04	5457.41
43	13121.86	00	00	1682.82	14804.68
44	00	00	00	17.53	17.53
45	17555.19	1030.15	2055.50	38234.99	58875.83
46	957.92	00	00	10454.50	11412.41
47	961.87	5.03	00	63.11	1030.00
48	55.42	1.76	00	140.23	197.41
49	839.17	71.36	5.20	3365.63	4281.36
50	00	00	00	4087.84	4087.84
51	316.67	00	00	273.46	590.12
52	961.87	00	00	00	961.87
53	15689.75	11.89	00	1859.19	17560.83
54	00	11.89	00	00	11.89
55	00	2.86	00	3973.45	3976.31
56	294.92	00	00	00	294.92
57	00	00	00	00	00
58	00	1.10	00	00	1.10
59	1460.59	508.59	444.56	3991.22	6404.96
60	00	00	00	00	00
61	641.53	0.25	1606.05	3213.99	5461.83
62	698.29	3.87	00	00	702.16
63	00	00	00	00	00
64	3.88	2.22	00	00	6.10
65	14706.19	912.76	19063.12	20311.97	54994.04
66	779.84	49.50	205.04	690.70	1725.08
67	00	00	00	00	00
68	1084.45	68.84	285.13	389.01	1827.43
69	24193.21	2042.06	7534.58	34524.27	68294.12
70	3308.73	210.02	869.96	2930.52	7319.23
71	1571.60	99.76	413.22	1391.96	3476.54
72	00	00	00	00	00
73	00	00	00	00	00
74	00	00	00	00	00
75	1965.69	124.77	516.84	1741.00	4348.29
76	00	00	00	00	00
77	478.25	30.36	125.74	423.58	1057.93
78	00	00	00	00	00
79	106.85	6.78	28.09	94.64	236.37
80	00	00	00	00	00
81	1833.71	116.39	482.13	1624.11	4056.35
82	95.98	6.09	25.24	85.01	212.31
83	195741.22	12748.76	27520.42	98747.02	334757.43
84*	396048.99	25257.00	106643.00	350340.00	878289.00

Footnote:
* Sector 84 is the sum of sectors 1-83 and equivalent to the total contract cost for each type project. The estimated contract cost for the multiple purpose project, 396048.99 is the rounding error of 396049.

$$\underset{(nm \cdot nm)}{T} = \begin{bmatrix} T^{11} & T^{12} & \cdots & T^{1n} \\ T^{21} & T^{22} & \cdots & T^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ T^{n1} & T^{n2} & \cdots & T^{nn} \end{bmatrix} \quad \text{and} \quad \underset{(m \cdot m)}{T^{gr}} = \begin{bmatrix} t_1^{gr} & & & 0 \\ & t_2^{gr} & & \\ & & \ddots & \\ 0 & & & t_m^{gr} \end{bmatrix}$$

where:

$n = 1 \ldots 4$ region,
g & r indicate shipping and receiving region respectively

$m = 1 \ldots 79$ industry

T^{gr} indicates a matrix of percentages of various commodities received by r region from g region (fixed column coefficients). t_1^{gr} indicates the proportion of the total receipts of the first industry product by region r from region g, where:

$$\sum_{g=1}^{4} t_1^{gr} = 1$$

By reading T^{g1} along the first colmn of the T matrix one can tell each proportion of total receipts for each commodity by the first region from various regions including its own region. The receiving region r indicates a project region, and T^{gr} differs when r changes. The matrix of trade coefficients for each commodity for the alternative impact region, are shown in Volume II.

Regional final demand vectors per $1,000 for each project type are estimated by multiplying the distribution pattern of each project contract cost by the trade coefficient matrix of an impact region with other regions. A matrix of regional final demand vectors for i^{th} project (Y_i^R) may be expressed in terms of $Y_i^R = Y_i T^R$, where Y_i and T^R indicate the total final demand pattern of i^{th} project and the trade pattern of the impact region R with other regions including his own for each industrial product. The regional demand vector of each region for the MKARMPP may be expressed in terms of a matrix of regional final demand vectors as $Y^R = YT$. The regional final demand vectors of the MKARMPP are shown in Table 7.

Of the total contract cost about 67 percent of its cost was spent within the project region. Of these 30 percent was for material and supplies and 37 percent was the wage and salaries for the on-site construction workers. The leakages to non-project regions was about 33 percent of the contract cost. Of this, 15 percent each went to the Southern Region and the rest of the United States, and three percent to the Northern Region.

TABLE 7
Regional Final Demand Vectors for the McClellan-Kerr Arkansas River Multiple Purpose Project Contract Cost*
(Unit $1,000 1963 Prices)

I/O Sector	National Demand Contract Cost	Regional Final Demands Region I	Region II	Region III	Region IV
1	00**	00	00	00	00
2	311.83	89.93	73.50	22.05	126.32
3	00	00	00	00	00
4	00	00	00	00	00
5	00	00	00	00	00
6	00	00	00	00	00
7	00	00	00	00	00
8	00	00	00	00	00
9	78708.30	41943.65	28366.47	6391.11	1999.19
10	00	00	00	00	00
11	00	00	00	00	00
12	00	00	00	00	00
13	00	00	00	00	00
14	00	00	00	00	00
15	00	00	00	00	00
16	00	00	00	00	00
17	60.93	2.16	29.50	1.38	27.89
18	00	00	00	00	00
19	11.66	.51	1.48	.65	9.02
20	8531.37	3107.98	3991.83	1.71	1429.86
21	00	00	00	00	00
22	00	00	00	00	00
23	181.33	12.73	34.34	10.25	123.96
24	287.93	19.32	77.25	35.50	155.83
25	00	00	00	00	00
26	59.42	24.20	16.37	.65	18.20
27	2881.76	282.70	1816.09	84.72	698.25
28	2.53	.12	1.31	.01	1.09
29	13.10	.28	1.03	3.71	7.98
30	369.83	14.90	51.63	40.24	263.10
31	15463.79	7770.55	6933.96	332.47	426.80
32	4128.42	208.07	925.18	382.29	2612.88
33	00	00	00	00	00
34	3.78	.27	.55	.55	2.41
35	00	00	00	00	00
36	65122.22	18592.39	28438.87	6655.49	11435.46
37	35607.49	2004.70	4458.06	2602.90	26541.81
38	2010.44	394.65	232.00	19.50	1364.28
39	00	00	00	00	00
40	45165.99	20866.69	13996.94	3035.15	7271.72
41	925.20	55.23	186.61	86.32	597.12
42	5457.41	971.42	1796.58	212.84	2476.57
43	14804.68	2350.98	635.12	34.05	11786.01
44	17.53	.53	3.11	.23	13.67
45	58875.83	8584.10	23850.60	947.90	25493.23
46	11412.41	269.33	4609.47	78.75	6454.86
47	1030.00	66.64	17.61	5.05	940.60
48	197.41	7.78	38.53	1.05	150.05
49	4281.36	1092.17	515.48	71.07	2602.64
50	4087.84	173.32	405.10	42.10	3467.30
51	590.12	113.95	66.45	2.54	407.12
52	961.87	549.23	199.30	6.44	206.99
53	17560.83	1754.33	1295.99	921.94	13588.57
54	11.89	3.66	.14	.17	7.92
55	3976.31	452.11	750.33	208.36	2565.52
56	294.92	82.49	55.56	7.11	149.73
57	00	00	00	00	00
58	1.10	.07	.20	.08	.75
59	6404.96	101.84	1331.59	2986.63	1984.90
60	00	00	00	00	00
61	5461.83	624.29	1289.54	758.10	2789.90
62	702.16	301.44	132.92	1.47	266.33
63	00	00	00	00	00
64	6.10	.93	1.27	00	3.91
65	54994.04	54994.04	00	00	00
66	1725.08	1725.08	00	00	00
67	00	00	00	00	00
68	1827.43	1827.43	00	00	00
69	68294.12	68294.12	00	00	00
70	7319.23	3664.74	2854.50	14.64	785.35
71	3476.54	3476.54	00	00	00
72	00	00	00	00	00
73	00	00	00	00	00
74	00	00	00	00	00
75	4348.29	4348.29	00	00	00
76	00	00	00	00	00
77	1057.93	1057.93	00	00	00
78	00	00	00	00	00
79	236.37	236.37	00	00	00
80	00	00	00	00	00
81	4056.35	4056.35	00	00	00
82	212.31	212.31	00	00	00
83	334757.43	334757.43	00	00	00
84***	878289.00	591542.27	129482.36	26007.17	131255.09
	(100%)	(67.35%)	(14.74%)	(2.96%)	(14.94%)

* Project Contract Cost is defined as the part of project cost expended through a private contract.

** "0" means insignificant.

Final Demand Vector for the Total MKARMPP Cost

In the previous section the final demand vector resulting from the MKARMPP is limited to the portion of contract construction cost, which is approximately 80 percent of the total project cost. As has already been explained, the remaining 20 percent of the project cost is non-contract cost, which consists of expenditures for land and damage expenses; engineering and design; and supervision and administration.[14] Although non-contract costs are not direct contract costs by private contractors, these expenditures are part of the total construction cost. To measure the total construction impact, therefore, the impact resulting from a non-contract cost must be included in addition to the impact resulting from a contract construction cost. For this reason final demand vectors for the total project expenditures are estimated.

Except for the compensation of land and damages, the non-contract costs of MKARMPP are primarily for the wages and salaries paid out by the District Engineers in the impact region. Although compensation for land and damages are not wages and salaries, these expenditures are also to be part of the household incomes of the project region.[15] So, in this study total non-contract costs for each project type of MKARMPP are treated as part of the household income of the project region.

The proportion of contract and non-contract costs and the distribution pattern of contract cost for each project are already known. Therefore, the total final demand vector, per $1,000 project cost, can be estimated by utilizing the basic distribution pattern of the project contract cost. The proportion of a contract cost to it's project cost multiplied by the distribution pattern per $1,000 of that contract cost becomes the distribution pattern of contract cost per $1,000 of the project cost. By adding the proportion of non-contract cost to the 83rd sector (household income) of the distribution pattern of the contract cost per $1,000 project cost, one can estimate the final demand vector per $1,000 project cost. Total final demand vectors by project type of the MKARMPP are shown in Table 8, and the regional final demand vectors are shown in Table 9.

Due to the increase in the household income of the project region by adding non-contract cost to household sector, about 74 percent of the total project cost was estimated to be spent in the project region. Although the absolute leakages from the project region remained the same but the proportion of the leakages to the project cost was reduced from 33 percent which was based on contract cost, to 26 percent of the total project cost.

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[14] The proportion of each component of non-contract cost varies from project to project. For the MKARMPP as a whole the proportion of each component of non-contract cost to total project cost are: 8.6% for land and damage, 5.7% for engineering and design, and 5.1% for supervision and administration.

[15] Some of the compensation for land and damage may be paid out to the property owners who are residing outside of an impact region. Some of the costs may be part of the taxes to the government. These facts are ignored in this study due to the lack of pertinent information. Therefore, the impact resulting from the household income may be overstated to a certain degree.

Table 8
National Final Demand Vectors for the McLellan-Kerr Arkansas River Multiple Purpose Project Costs
(Unit $1,000 1963 Prices)

	Project Category				
I/O Sector	Multiple Purpose	Flood Control	Revetments	Locks & Dams	Total Project
1	00	00	00	00	00
2	00	6.32	00	305.51	311.83
3	00	00	00	00	00
4	00	00	00	00	00
5	00	00	00	00	00
6	00	00	00	00	00
7	00	00	00	00	00
8	00	00	00	00	00
9	17775.12	1124.39	34559.74	25250.05	78709.30
10	00	00	00	00	00
11	00	00	00	00	00
12	00	00	00	00	00
13	00	00	00	00	00
14	00	00	00	00	00
15	00	00	00	00	00
16	00	00	00	00	00
17	60.69	0.24	00	00	60.93
18	00	00	00	00	00
19	00	8.12	00	3.54	11.66
20	2181.57	277.91	4550.57	1521.45	8531.50
21	00	00	00	00	00
22	00	00	00	00	00
23	180.30	1.04	00	00	181.34
24	287.95	00	00	00	287.95
25	00	00	00	00	00
26	59.42	00	00	00	59.42
27	2411.06	60.43	00	410.40	2881.89
28	00	2.53	00	00	2.53
29	00	13.10	00	00	13.10
30	21.72	1.84	00	346.27	369.83
31	4841.32	669.98	4772.92	5179.85	15464.06
32	2442.05	161.68	292.93	1231.90	4128.56
33	00	00	00	00	00
34	00	00	00	3.78	3.78
35	00	00	00	00	00
36	22844.52	1659.74	23.07	40596.16	65123.50
37	12449.67	116.36	181.79	22860.35	35608.17
38	1288.03	7.77	182.83	531.88	2010.51
39	00	00	00	00	00
40	27342.18	2766.92	20.30	15038.10	45167.51
41	57.91	2.21	00	865.08	925.20
42	2385.97	309.51	878.03	1884.04	5457.54
43	13122.56	00	00	1682.82	14805.38
44	00	00	00	17.53	17.53
45	17556.13	1030.16	2055.50	38235.02	58876.81
46	957.97	00	00	10454.50	11412.47
47	961.93	5.03	00	63.11	1030.06
48	55.42	1.76	00	140.23	197.41
49	839.21	71.36	5.20	3365.64	4281.41
50	00	00	00	4087.84	4087.84
51	316.68	00	00	273.46	590.14
52	961.93	00	00	00	961.93
53	15690.58	11.89	00	1859.19	17561.67
54	00	11.89	00	00	11.89
55	00	2.86	00	3973.45	3976.31
56	294.94	00	00	00	294.94
57	00	00	00	00	00
58	00	1.10	00	00	1.10
59	1460.67	508.60	444.56	3991.22	6405.05
60	00	00	00	00	00
61	641.57	0.25	1606.05	3213.99	5461.86
62	698.33	3.87	00	00	702.19
63	00	00	00	00	00
64	3.88	2.22	00	00	6.10
65	14706.98	912.77	19063.13	20311.99	54994.86
66	779.88	49.50	205.04	690.70	1725.12
67	00	00	00	00	00
68	1084.50	68.84	285.13	389.02	1827.49
69	24194.50	2042.09	7534.59	34524.29	68295.47
70	3308.90	210.03	869.96	2930.52	7319.41
71	1571.69	99.76	413.22	1391.96	3476.63
72	00	00	00	00	00
73	00	00	00	00	00
74	00	00	00	00	00
75	1965.79	124.77	516.84	1741.00	4348.40
76	00	00	00	00	00
77	478.27	30.36	125.75	423.58	1057.96
78	00	00	00	00	00
79	106.86	6.78	28.09	94.64	236.37
80	00	00	00	00	00
81	1833.81	116.40	482.14	1624.11	4056.45
82	95.98	6.09	25.24	85.01	212.32
83	320963.57	31974.54	44996.39	153330.84	551265.34
84*	521282.00	44483.00	124119.00	404924.00	1094808.00

Footnote:
* Sector 84 is the sum of sectors 1-83 and equivalent to the total project cost for each type project.

TABLE 9
Regional Final Demand Vectors for the McClellan-Kerr
Arkansas River Multiple Purpose Project Cost
(Unit $1,000 1963 Prices)

I/O Sector	National Final Demand Project Cost	Regional Final Demand Region I	Region II	Region III	Region IV
1	00*	00	00	00	00
2	311.83	89.93	73.50	22.05	126.32
3	00	00	00	00	00
4	00	00	00	00	00
5	00	00	00	00	00
6	00	00	00	00	00
7	00	00	00	00	00
8	00	00	00	00	00
9	78709.30	41944.19	28366.83	6391.20	1999.22
10	00	00	00	00	00
11	00	00	00	00	00
12	00	00	00	00	00
13	00	00	00	00	00
14	00	00	00	00	00
15	00	00	00	00	00
16	00	00	00	00	00
17	60.93	2.16	29.50	1.38	27.89
18	00	00	00	00	00
19	11.66	.51	1.48	.65	9.02
20	8531.50	3108.03	3991.89	1.71	1429.88
21	00	00	00	00	00
22	00	00	00	00	00
23	181.34	12.74	34.34	10.25	123.96
24	287.95	19.32	77.26	35.50	155.84
25	00	00	00	00	00
26	59.42	24.20	16.37	.65	18.20
27	2881.89	282.71	1816.17	84.73	698.28
28	2.53	.12	1.31	.01	1.09
29	13.10	.28	1.03	3.71	7.98
30	369.83	14.90	51.63	40.24	263.10
31	15464.06	7770.69	6934.08	332.48	426.81
32	4128.56	208.08	925.21	382.30	2612.97
33	00	00	00	00	00
34	3.78	.27	.55	.55	2.41
35	00	00	00	00	00
36	65123.50	18592.76	28439.43	6655.62	11435.69
37	35608.17	2004.74	4458.14	2602.96	26542.33
38	2010.51	394.66	232.01	19.50	1364.33
39	00	00	00	00	00
40	45167.51	20867.39	13997.41	3035.26	7271.97
41	925.20	55.23	186.61	86.32	597.12
42	5457.54	971.44	1796.62	212.84	2476.63
43	14805.38	2351.09	635.15	34.05	11786.56
44	17.53	.53	3.11	.23	13.67
45	58876.81	8584.24	23851.00	947.92	25493.66
46	11412.47	269.33	4609.50	78.75	6454.89
47	1030.06	66.64	17.61	5.05	940.65
48	197.41	7.78	38.53	1.05	150.05
49	4281.41	1092.19	515.48	71.07	2602.67
50	4087.84	173.32	405.10	42.10	3467.30
51	590.14	113.96	66.45	2.54	407.14
52	961.93	549.26	199.31	6.44	207.00
53	17561.67	1754.41	1296.05	921.99	13589.22
54	11.89	3.66	.14	.17	7.92
55	3976.31	452.11	750.33	208.36	2565.52
56	294.94	82.49	55.57	7.11	149.74
57	00	00	00	00	00
58	1.10	.07	.20	.08	.75
59	6405.05	101.84	1331.60	2986.67	1984.92
60	00	00	00	00	00
61	5461.86	624.29	1289.55	758.11	2789.92
62	702.19	301.45	132.92	1.47	266.34
63	00	00	00	00	00
64	6.10	.93	1.27	00	3.91
65	54994.86	54994.86	00	00	00
66	1725.12	1725.12	00	00	00
67	00	00	00	00	00
68	1827.49	1827.49	00	00	00
69	68295.47	68295.47	00	00	00
70	7319.41	3664.83	2854.57	14.64	785.37
71	3476.63	3476.63	00	00	00
72	00	00	00	00	00
73	00	00	00	00	00
74	00	00	00	00	00
75	4348.40	4348.40	00	00	00
76	00	00	00	00	00
77	1057.96	1057.96	00	00	00
78	00	00	00	00	00
79	236.37	236.37	00	00	00
80	00	00	00	00	00
81	4056.45	4056.45	00	00	00
82	212.32	212.32	00	00	00
83	551265.34	551265.34	00	00	00
84**	1094808.00 (100%)	808055.18 (73.81%)	129484.81 (11.83%)	26007.71 (2.38%)	131258.24 (11.99%)

* "0" means insignificant

** Sum of sector 1-83 which is the project cost. The sum of regional final demands may not equal the national final demand due to rounding errors.

Chapter IV

Impact Evaluation

Final demand vectors estimated from the MKARMPP in the previous chapter have been applied to the IRIO in measuring the economic impact of the project on the regional and national economies. Prior to the evaluation of economic expansion, given the final demand vectors, various multipliers are evaluated first. Following the evaluation of the multipliers the economic impact of the project, in terms of per $1,000 MKARMPP cost, is evaluated. The sensitivity of the impacts of various hypothetical types of water resources investments in different regions is also investigated. The evaluation of the economic interdependencies through 80 industrial sectors, with 4 internal regions, requires the operation of a 320 X 320 matrix size and is very expensive in evaluating various multipliers and sensitivity analysis. The large matrix is convenient for the evaluation of detailed structural relationships at the disaggregated industrial level, but a disaggregated industrial sector model is more useful in evaluating the general characteristics of structural relationships. For these reasons we have used a 10 industrial sector I/O model (11 sectors for the closed model)[1] for the most part of the impact evaluation. An 80 sector model is used only for the evaluation of the economic impact on the level of output and income resulting from the MKARMPP.

Analysis of Multipliers

Input-Output Multipliers are probably the most important tool used in local and regional economic impact analysis. The Keynesian income multiplier developed in macroeconomic theory contributes in measuring the expansionary impact of change in investments (or government expenditures or exports) on national or local economy on an aggregated basis. In the Keynesian model the pattern of expenditure and the discriminatory impacts of these expenditures on different sectors of industry and interindustrial and interregional interdependencies are not important. An Input-Output model, on the other hand, enables us to study interindustry and interregional dependencies as well as to derive sector multipliers for output, income and employment at the desired disaggregated industrial level.[2] Since the impact of any

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[1] Because of the evaluation of Type I & II multipliers both open and closed I/O models with aggregated industrial sectors are used. For the convenience of designation, the aggregated I/O model for industrial sectors is defined as a 10 sector model regardless of whether it's an open or closed model. The I/O model with 79 industrial sectors, is defined as an 80 sector model. For the sector classification see Table 1, Chapter 2.

[2] This, of course, depends on availability of input-output data for the desired disaggregated industrial level. The greater detailed information from the I/O model, of course, requires more time and cost.

change in investment, the overall investment impact depends upon sector multipliers, the size and the pattern of investment mix.

The basic data sources for various multipliers are (1) regional technical coefficients (A), (2) interregional trade coefficients (T), (3) interregional direct requirements (TA), (4) interregional direct and indirect requirements $(I-TA)^{-1}$ and (5) interregional direct, indirect, and induced requirements $(I-T_HA_H)^{-1}$. While technical coefficients provide the information of direct input requirements from various supplying industries in order to produce one dollar's worth of output by a purchasing industry disregarding their regional origin, interregional direct requirements provide the regional origin of these inputs. One can find direct and indirect requirements from various supplying industries in various regions to yield a dollar's worth of output to final users by a purchasing industry in a region. This information is obtained from a table derived by inverting the matrix (I-TA). The direct, indirect, and induced requirements are obtained by inverting the matrix $(I-T_HA_H)$, where T_HA_H includes the household sector in the TA matrix. Except the interregional direct and indirect requirements for the 80 sector model, all data listed in the above for both the 10 and 80 sector models are collected in Volume II. These requirements, themselves, constitute various multipliers.[3] In this study the output and income multipliers for both Type I and Type II for 10 sector models will be evaluated.

Output Multipliers

The output multiplier for the i^{th} industry measures the total requirements from all sectors needed to deliver one additional dollar of output i to the final users. Type I multiplier measures the sum of direct and indirect requirements; on the other hand, Type II multiplier measures direct, indirect, and induced requirements. The Type I multiplier is derived by summing the column entries of the $(I-TA)^{-1}$ matrix under i^{th} industry, and the Type II multiplier is derived by summing the same column entries of the $(I-T_HA_H)^{-1}$ matrix. Since output includes both industrial and final demand, the output multiplier indicates linkage effects of each industry. The higher the multiplier the higher the industry's linkage with other industries. The output multiplier in this study is a joint product of (a) production function of an industry in a particular region; (b) linkage effect of an industry; and (c) trade relation of an industry with other regions. The output multipliers evaluated for the IRIO model are shown in Table 10.

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[3] For a more detailed discussion of various types of multipliers, see Harry W. Richardson, Input-Output and Regional Economics, London: Weidenfeld and Nicolson, 1972, pp. 29-52.

TABLE 10

OUTPUT MULTIPLIERS

Industry/Region	Region I	Region II	Region III	Region IV
1. Agri., For. & Fish.	2.19902	2.02980	2.37113	2.12281
	5.78306	5.14996	5.77354	5.46875
2. Mining	1.63057	1.57140	1.59091	1.59654
	5.23693	4.51719	4.99726	4.66353
3. Construction	2.02453	2.14464	2.00639	2.02987
	6.44788	5.99102	6.27432	6.20891
4. Nondur. Mfg.	2.25639	2.11513	2.27766	2.16246
	5.59966	5.02116	5.83330	5.65134
5. Dur. Mfg.	1.98911	1.95374	2.10878	1.98400
	6.09052	5.48312	6.05943	5.78564
6. Trans., Comm. & Util.	1.54337	1.54079	1.53776	1.51712
	5.26393	4.62095	5.09742	4.83282
7. Trade	1.35870	1.36581	1.36892	1.36295
	5.41506	4.81465	5.17702	5.08862
8. Fin., Ins. & R.E.	1.38815	1.40782	1.38748	1.40161
	3.76161	3.43887	3.65399	3.67680
9. Services	1.53605	1.52383	1.50295	1.50103
	5.43256	4.93757	5.21719	5.15657
10. Govt. Enterprises	1.54217	1.56441	1.51093	1.56849
	6.55986	5.81570	6.20885	6.16896

Note: The first row of each industry shows Type I output multiplier, and the second row of each industry shows Type II output multiplier.

(1) Type I Output Multipliers

Type I multipliers are shown in the first row in Table 10 for each industrial sector. These multipliers are derived by summing the column entries of $(I-TA)^{-1}$ matrix under each industrial sector in each region. The multipliers under each region represent differences in multipliers when the output is produced in each different region. For example, in order to deliver a dollar's worth of agriculture, forestry and fishery products to final users by Region I (the Impact Region), the direct and indirect requirements from various industrial sectors and regions would be approximately \$2.20. If this delivery was made by Regions II, III, and IV the requirements would be \$2.03, \$2.37, and \$2.12 respectively. Expressed differently, an increase in the demand for one dollar of agricultural output by the final use may increase output of the economy from 2.03 times to 2.37 times depending on where the output is produced. The multiplier is highest for this industry when the output is produced in Region III and lowest when it is produced in Region II.

The rank order of multipliers among industries in Region I is non-durable manufacturing (2.25), agriculture, forestry and fishery combined (2.20), construction (2.02), durable manufacturing (1.99), mining (1.63), transportation, communication and utilities combined (1.54), government enterprises (1.54), services (1.53), finance insurance and real estate combined (1.53), and the trade sector (1.35). Variations of multipliers for the same industry among different regions are generally not significant.

(2) Type II Output Multipliers

Type II output multipliers are derived by summing column entries of $(I-T_H A_H)^{-1}$ matrix for each industry and region and are shown in the second row for each industrial sector in Table 10. Type II output multiplier represents the total direct, indirect, and induced requirements to deliver a dollar's worth of output of the i^{th} industry in the j^{th} region to the final users. Since the additional induced impact resulting from the consumption expenditures on the economy is added to each type I multiplier, each type II multiplier is expected to be greater than its type I counterpart. The range of type II multipliers among industrial sectors in Region I is from 5.23 (mining) to 6.56 (government enterprises). The rate of increase from the type I multiplier by adding induced impact differs significantly among industries. The industrial multipliers which increased more than three times are: government enterprise, trade, services, transportation communication and utilities combined, mining and durable manufacturing sectors. Consequently the pattern of ranking of type II multipliers has changed significantly from type I multipliers. The government enterprise, construction, durable manufacturing and non-durable manufacturing sector multipliers are among the highest. Except the finance, insurance and real estate sector, all type II multipliers exceed 5, but due to the counteracting effects of induced impacts the variations in the size of multipliers among industries is less than that of type I multipliers. The variation of the same sector

multipliers among different regions demonstrates a larger absolute variation compared to type I multipliers, but the relative variation is again insignificant.

Income Multipliers

The output multiplier is convenient in measuring total shipment and linkage effects, but it does not measure the impact in terms of income which is a more convenient form of the economic growth index. Income multipliers are also derived from the basic tables discussed in the beginning of this chapter. As in the output multipliers, income multipliers are classified into type I and type II multipliers and the meanings of these multipliers are analogous to those of the output multipliers.[4]

(1) Type I Income Multiplier

The type I income multiplier is expressed as the ratio of the direct plus the indirect income changes to the direct income change resulting from a dollar increase in final demand for any given sector. The direct income change for each industrial sector is given by household row entry of the interregional I/O table and direct requirements table in terms of household coefficients.

The direct and indirect income change is derived by multiplying each column entry of an industrial sector in a region in the $(I-TA)^{-1}$ matrix by the supplying industry's corresponding household row coefficient from the direct requirements table and summing the multiplied results along the column. Type I income multiplier represents the direct and indirect change in income resulting from a dollar increase *in direct* income. It is worth noting that this income results from a dollar change in direct income but not a dollar increase in final demand. To increase direct income by a dollar, the final demand must increase more than a dollar.

Type I income multipliers for the IRIO are shown in Table 11 in the first row for each industry. Consider the income multiplier for the sector of agriculture, forestry and fishery combined. An increase of a dollar's worth direct income by the agriculture, forestry and fishery sector in Region I to satisfy the final users for the same industrial product, will ultimately generate \$2.2 income. The level of income would be \$2.1, \$2.9, and \$2.3 if the output were produced in Region II, III, and IV respectively.

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[4] Since the household row and column coefficient for the I/O model is constructed to equate total household income to consumption expenditures, the income derived in this study is less than national income. Thus, in this study, the term income refers to household income.

The range of multiplier among industrial sectors in Region I is from the trade sector (1.22) to the non-durable manufacturing sector (2.98). The sector multipliers which are approximately equal to or are greater than two are: non-durable manufacturing, agriculture, forestry and fishery sector, durable manufacturing and construction sectors. The variation of multipliers for the same industry among different regions is not significant, except for the first industrial sector with a maximum range of 0.7.

(2) Type II Income Multipliers

Type II income multipliers are shown in Table 11 in the second row for each industry. Type II multipliers are derived by dividing the direct, indirect, and induced income changes by the direct income change resulting from the increase of a dollar's worth delivery by an industry to the final users in a region. The direct, indirect, and induced income changes to yield a dollar's worth of i^{th} output in j^{th} region of final users is shown in the household row entries in the $(I-T_H A_H)^{-1}$ matrix. Income changes due to the delivery of one dollar's output by the 1st industrial sector in Region I is the sum of the four household rows under the first industry of $(1-T_H A_H)^{-1}$ matrix. The direct income change is shown in the direct requirements table.

As in the case of output multipliers, the type II multipliers are greater than their type I counterparts. The induced impacts on multipliers vary among industries, but not as much as in the case of output multipliers. Type II multiplier is little more than double type I multiplier for every sector. The range of type II multipliers among sectors in Region I is from 2.8 (trade) to 6.7 (non-durable manufacturing). In addition to non-durable industry agriculture, forestry and fishery combined (6.08), durable manufacturing (4.36) and construction (4.28) industries show relatively high multipliers. Unlike the case of output multipliers, induced impact does not change the ranking of the initial type I multipliers.

The variation of multipliers among different regions for the same industry shows insignificant variation.

The Impact of MKARMPP Through 10 Sector Model

In this section the impact of MKARMPP on regional and national economies in terms of level of output and income for ten industrial sectors will be evaluated. Since the MKARMPP cost is classified into both contract cost and project cost, the impact will be estimated for both types of cost. For the convenience of the structural evaluation among industries and regions, the evaluation is made per $1,000 investment cost. One can find the total impact resulting from MKARMPP if one multiplies the impact by the total project contract cost (or project cost) in units of $1,000. For

TABLE 11

INCOME MULTIPLIERS

Industry/Region	Region I	Region II	Region III	Region IV
1. Agr., Forest. & Fish.	2.27713	2.12542	2.97599	2.31488
	6.08270	5.71161	6.04444	5.97629
2. Mining	1.49909	1.47042	1.48082	1.59913
	3.42998	3.20224	3.36352	3.61636
3. Construction	1.87879	2.23646	1.87709	1.95177
	4.28779	4.91308	4.25973	4.41504
4. Nondurable Mfg.	2.98706	2.85582	2.64156	2.37931
	6.76422	6.26454	5.98596	5.37867
5. Durable Mfg.	1.91560	2.00210	2.20255	2.01413
	4.36669	4.39938	4.99484	4.55592
6. Transp., Comm. & Util.	1.47775	1.49894	1.47640	1.47591
	3.38732	3.26306	3.35419	3.33886
7. Trade	1.22983	1.24406	1.25173	1.24713
	2.82283	2.70509	2.84520	2.82207
8. Fin., Ins. & R.E.	1.51243	1.54235	1.52485	1.53209
	3.46755	3.35817	3.46539	3.46678
9. Services	1.40950	1.40047	1.38493	1.38524
	3.23022	3.05131	3.14690	3.13439
10. Govt. Enterprises	1.31476	1.32714	1.30602	1.34395
	3.01744	2.88723	2.96830	3.04085

Note: The first row of each industry shows type I income multiplier, and the second row of each industry shows type II income multiplier.

example, the total impact of MKARMPP contract cost is obtained by multiplying the impact measured per $1,000 contract cost by $878,289.[5]

(1) Evaluation of the Project Impact Based on Contract Cost

The demand patterns of water resource investment by 12 different types, based on their contract cost, are aggregated into 11 sectors in Table 12. The demand patterns for input for the construction of a project vary among project types. The MKARMPP is a combination of four different types of water resource projects. The input demand for the MKARMPP, without considering the region of origin, is defined as national final demand for the MKARMPP and its distribution pattern by industrial sector, per $1,000 contract cost, is shown in Table 13. The demand for labor is the single largest sector ($386) followed by manufacturing goods ($324). The total contract cost is broken down among various project types: $450 for multiple purpose project; $29 for flood control; $121 for revetments; and $400 for locks and dams. The requirements for the input by industry also varies greatly among types of projects.

Due to the trade pattern of the impact region, as explained in the previous chapter, the total project demand for input will not be produced in the impact region. The regional final demand was defined as the actual requirements for the production of goods and services imposed on the various regions for the delivery of their products to the impact region for the construction of the project. The actual share of the delivery of each input depends upon the demand pattern of the project and the degree of the economic reliance of the project region upon other trading regions. Table 13 shows that the estimated input demands for the project which would be imposed on various regions for the production are: $632; $140; $38; $190 by the Impact, Southern, Northern and Rest of the U.S. Regions respectively. This pattern is somewhat different from when the 80 sector model was applied in the previous chapter. The share of the Impact Region has declined by about $40 and this amount was added to the share of the Rest of the U.S. Region. This change has been attributed to the fact that the final demand vectors and trade patterns have been aggregated into 10 sector model. For example, in the 80 sector model the requirements for mining products consist of only stone and clay products (sector 9) and were supplied solely by the project region. However, due to the aggregation of the model, the same products are estimated to be delivered by all regions according to the average trade flow patterns for total mining products of the project region with other regions. Therefore, in the aggregation model, some deviation of the demand pattern from the disaggregated model was expected.

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[5] For the various types of costs for MKARMPP, see Table 4, Chapter 3, in this report.

TABLE 12
NATIONAL FINAL DEMAND PATTERN PER $1,000
CONTRACT COST FOR WATER RESOURCE INVESTMENT BY PROJECT TYPE (10 SECTOR MODEL)
(Unit: 1963 Dollars)

		Multiple Purpose Project Includ. Power-house	Dredging	Large Earth Fill Dam	Small Earth Fill Dam	Local Flood Protect.	Pile Dikes	Levees	Revet-ment	Power-house	Medium Concrete Dam	Lock and Dam	Misc.
1	Agr, Forst & Fish	0.00	0.00	0.16	0.81	0.25	0.00	0.22	0.00	0.02	0.05	0.87	1.00
2	Mining	44.88	0.01	0.26	25.81	44.52	131.07	77.87	324.07	9.38	1.71	72.07	24.59
3	Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Nondurbl Mfg	31.52	108.17	108.76	117.34	47.39	99.67	95.25	90.17	19.52	24.40	24.82	143.91
5	Durbl Mfg	302.80	244.96	261.91	280.16	257.88	131.54	105.02	50.61	631.14	356.46	437.10	258.09
6	Transp, Comm & Utl	41.84	20.61	19.31	34.24	40.82	87.15	54.54	183.35	25.78	36.15	61.06	36.43
7	Trade	61.09	54.57	113.58	115.42	80.85	67.86	54.25	70.65	93.06	83.07	98.55	104.81
8	Financ, Insur & Real Est	12.32	12.15	12.26	12.29	12.27	12.17	12.08	12.03	12.77	12.32	12.34	12.24
9	Services	6.17	6.08	6.14	6.15	6.14	6.09	6.05	6.03	6.39	6.17	6.18	6.13
10	Government Entpr	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.28	0.27	0.27	0.27
11	Household Income	499.11	553.18	477.37	407.51	509.61	464.19	594.46	262.82	201.66	479.39	286.74	412.53
12	Sum of 1-11	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00

Table 13

NATIONAL AND REGIONAL FINAL DEMANDS PER $1000 FOR THE MCCLELLAN-KERR ARKANSAS RIVER MULTIPLE PURPOSE PROJECT CONTRACT COST (Unit 1963 Dollars)

NATIONAL FINAL DEMAND

I/O Sector	Project Category: Multiple Purpose	Flood Control	Revetments	Lock and Dams	Total Project
1	0.00	0.01	0.00	0.35	0.36
2	20.24	1.28	39.35	28.75	89.62
3	0.00	0.00	0.00	0.00	0.00
4	14.22	1.36	10.95	9.90	36.43
5	136.54	7.42	6.15	174.35	324.46
6	18.87	1.17	22.26	24.36	66.66
7	27.55	2.33	8.58	39.31	77.76
8	5.56	0.35	1.46	4.92	12.29
9	2.78	0.18	0.73	2.46	6.16
10	0.12	0.01	0.03	0.11	0.27
11	225.06	14.66	31.91	114.38	386.01
Total	450.93	28.66	121.42	398.89	1000.00

REGIONAL FINAL DEMAND

I/O Sector	Region I	Region II	Region III	Region IV	Nation
1	0.11	0.12	0.02	0.10	0.36
2	17.37	61.60	3.40	7.25	89.62
3	0.00	0.00	0.00	0.00	0.00
4	9.61	11.58	2.71	12.53	36.43
5	59.28	64.73	32.36	168.08	324.46
6	66.66	0.00	0.00	0.00	66.66
7	77.76	0.00	0.00	0.00	77.76
8	10.35	1.51	0.01	0.42	12.29
9	4.33	0.72	0.00	1.10	6.16
10	0.27	0.00	0.00	0.00	0.27
11	386.01	0.00	0.00	0.00	386.01
Total	631.75	140.27	38.49	189.49	1000.00

The regional demand indicates the economic structures of the project region with other regions in terms of the direction and magnitude of leakages by each industrial sector. The demand for labor, transportation and service are generally considered to be self-sufficient but the manufacturing goods heavily rely upon outside regions, especially on the Rest of the U.S.

Table 14 shows the level of output expansion per $1,000 project contract cost using a closed I/O model. For the nation as a whole, the investment of $1,000 MKARMPP contract cost has been estimated to increase the output by $5705. That is, for the total economy the transaction has been expanded almost six times. The word transaction is used, since the output is measured on a shipment basis rather than an income basis. This output resulted from the interaction of two factors: 1) the trade pattern of the project region and 2) the production function of each region of this model. It is also the result of direct, indirect, and induced impacts of the project.

The regional shares of the total output are: 30, 18, 5, and 47 percent by the Impact, Southern, Northern and the Rest of the U.S. Regions respectively. The share of each industrial output by each region is also shown in the same table. As one will notice, the share of output by industry and region is somewhat different from those of the regional demand pattern imposed on each region. The extreme shares except the household income sector, have been absorbed by other industrial sectors. This is attributed to the differences of linkage effects among industries and is due to household spending patterns.

The regional shares of industrial output as a whole slightly differs from those of final demands. For example, the share of final demand by the Impact Region was 63 percent of the national demand, but the output share declined to 30 percent. The same figures for the Rest of the U.S. increased from 20 percent to 47 percent. This phenomena is probably attributed to the size of region and the degree of self-sufficiency in economic structures. The more open the economy, the more leakages and vice versa.

The 11th sector represents household income[6] generated during the process of increasing output resulting from construction expenditures. The total household income which results from $1,000 construction expenditures is $1740, 45 percent of which was shared by the Impact Region, 38 percent by the Rest of the U.S. and 17 percent by the other two regions.

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6 The household income defined here is the income expendable for the consumption of goods and services. Therefore, the household income is smaller than the national income. The way in which the household income coefficients are derived was explained in Chapter 2.

Table 14

OUTPUT RESULTING FROM THE MCCLELLAN-KERR
ARKANSAS MULTIPLE PURPOSE PROJECT CONTRACT COST
(PER $1000 BY INDUSTRY AND REGION
(Unit 1963 Dollars)

Industry	Region I	Region II	Region III	Region IV	Nation	
1	11.17	27.61	14.28	111.89	164.95	
	(6.8)*	(16.7)	(8.6)	(67.8)	(100)	2.9
2	22.12	117.64	6.61	39.39	185.75	
	(11.9)	(63.3)	(3.6)	(21.2)	(100)	3.3
3	19.54	15.25	2.51	25.17	62.46	
	(31.3)	(24.4)	(4.0)	(40.3)	(100)	1.1
4	84.37	188.68	49.42	533.15	855.62	
	(9.9)	(122.1)	(5.8)	(62.3)	(100)	15.0
5	83.11	119.68	62.92	564.16	829.87	
	(10.0)	(14.4)	(7.6)	(68.0)	(100)	14.5
6	172.72	50.47	12.49	129.91	365.58	
	(47.3)	(13.8)	(13.4)	(35.5)	(100)	6.4
7	269.45	67.63	18.78	195.56	551.43	
	(48.9)	(12.3)	(3.4)	(35.5)	(100)	9.7
8	168.57	116.00	19.79	211.50	515.86	
	(32.7)	(22.5)	(3.8)	(41.0)	(100)	9.0
9	117.36	71.42	14.84	207.18	410.80	
	(28.6)	(17.4)	(3.6)	(50.5)	(100)	7.2
10	7.97	3.60	0.86	9.80	22.24	
	(35.8)	(16.2)	(3.9)	(44.1)	(100)	0.4
11	780.35	235.59	62.94	661.89	1740.76	
	(44.8)	(13.5)	(3.6)	(38.0)	(100)	30.5
Total	1736.73	1013.57	265.44	2689.59	5705.33	
	(30.4)	(17.8)	(4.7)	(47.1)	(100)	100

* Except the last column each figure in the ( ) shows the percentage of national output by each industry by region. The figures in the ( ) in the last row are the regional shares of total national industrial output by each region.

The total impact of the MKARMPP contract cost is derived by multiplying the above impacts per $1,000 contract cost by the total contract cost in thousand dollars which is $878,289. The total impact of the MKARMPP contract cost is estimated to be $5,010,638,745 in terms of output or $1,528,890,359 in income.

(2) Evaluation of the Project Impact Based on Project Cost

The impact study of the MKARMPP based on the contract cost does not include the impact resulting from the non-contract cost of the project. Since the contract cost is equivalent to about 80 percent of the project cost in the MKARMPP, the project impact based on the contract cost is underestimated by at least 20 percent[7] compared to that based on the project cost. It also overlooks the impact of non-contract costs on the economic structures. In this section the impact per $1,000 MKARMPP project cost will be evaluated through the same process as the evaluation of the contract cost. The only difference is that non-contract costs are added to the household income sector, because the non-contract costs are primarily wages and salaries for the on-site labor and employees of District Engineers for the design and administration of the project.

As shown in Table 15, the direct household income per $1,000 project cost is increased to $507 from $386 compared to the case of contract cost. Of course the magnitude of the increase in direct household income is different among various types of projects. Due to the increase in non-contract costs in the project region, the share of input delivery within the project region has increased by 7 percent, from 63 percent to 70 percent. The output resulting from per $1,000 MKARMPP project cost is shown in Table 16. The total output for the nation is $5780 and was increased by $75 as compared to that based on the contract cost. However, the income generated from the project cost has increased from $1740 to $1850, an increase of $110. The share of income by the project region has increased by 3 percent or $140. The share of national output by industry and region other than household sector, has also altered slightly and is shown in the same table.

To estimate the impact of the total MKARMPP cost instead of per $1,000 project contract cost the various impacts which were evaluated in this section must be multiplied by 1,094,808, which is the total MKARMPP cost in thousand dollars. The total output resulting from the MKARMPP for the nation as a whole is estimated to be $6,327,979,291, in 1963 prices. About 33 percent of the output ($2.1 billion) is estimated to be attributable to the Impact Region. The household income generated through the construction investments is estimated to be $2,026,785,206 (2 billion), about 50 percent of which ($0.9 billion) is attributable to the Impact Region.

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[7] For the ratio of the contract cost of MKARMPP to the total project cost see Table 4 in Chapter 3.

Table 15

NATIONAL AND REGIONAL FINAL DEMANDS PER $1000 FOR THE MCCLELLAN-KERR
ARKANSAS RIVER MULTIPLE PURPOSE PROJECT COST
(Unit: 1963 Dollars)

NATIONAL FINAL DEMAND

Project Category

I/O Sector	Multiple Purpose	Flood Control	Revetments	Lock and Dams	Total Project
1	0.00	0.01	0.00	0.28	0.28
2	16.24	1.03	31.57	23.06	71.89
3	0.00	0.00	0.00	0.00	0.00
4	11.40	1.09	8.78	7.94	29.23
5	109.54	5.95	4.93	139.87	260.30
6	15.14	0.94	17.86	19.54	53.48
7	22.10	1.87	6.88	31.53	62.38
8	4.46	0.28	1.17	3.95	9.86
9	2.23	0.14	0.59	1.98	4.94
10	0.10	0.01	0.03	0.09	0.22
11	294.93	29.32	41.56	141.61	507.43
Total	476.14	40.63	113.37	369.86	1000.00

REGIONAL FINAL DEMAND

I/O Sector	Region I	Region II	Region III	Region IV	Nation
1	0.09	0.10	0.02	0.08	0.28
2	13.93	49.42	2.73	5.81	71.89
3	0.00	0.00	0.00	0.00	0.00
4	7.71	9.29	2.17	10.06	29.23
5	47.56	51.93	25.96	134.84	260.30
6	53.48	0.00	0.00	0.00	53.48
7	62.38	0.00	0.00	0.00	62.38
8	8.31	1.22	0.01	0.33	9.86
9	3.48	0.58	0.00	0.88	4.94
10	0.22	0.00	0.00	0.00	0.22
11	507.43	0.00	0.00	0.00	507.43
Total	704.57	112.53	30.88	152.02	1000.00

Table 16

OUTPUT RESULTING FROM THE MCCLELLAN-KERR
ARKANSAS RIVER MULTIPLE PURPOSE PROJECT COST
(PER $1,000) BY INDUSTRY AND REGION
(Unit 1963 Dollars)

Industry	Region I	Region II	Region III	Region IV	Nation	
1	12.41	29.56	14.91	114.32	171.20	
	(7.2)*	(17.3)	(8.7)	(66.8)	(100)	3.0
2	18.84	106.71	5.96	37.33	168.85	
	(11.2)	(63.2)	(3.5)	(22.1)	(100)	2.9
3	20.96	14.96	2.41	24.50	62.83	
	(33.4)	(23.8)	(3.8)	(39.0)	(100)	1.1
4	93.33	199.17	51.57	536.98	881.05	
	(10.6)	(22.6)	(5.6)	(60.9)	(100)	15.2
5	72.77	106.55	55.88	511.24	746.44	
	(9.7)	(14.3)	(7.5)	(68.5)	(100)	12.9
6	170.87	49.81	12.02	125.39	358.09	
	(47.7)	(13.9)	(3.4)	(35.0)	(100)	6.2
7	286.60	66.26	18.00	188.71	559.56	
	(51.2)	(11.8)	(3.2)	(33.7)	(100)	9.7
8	189.93	116.14	19.00	205.89	530.96	
	(35.8)	(21.9)	(3.6)	(38.8)	(100)	9.2
9	133.67	73.30	14.28	205.66	426.90	
	(31.3)	(17.2)	(3.3)	(48.2)	(100)	7.4
10	8.89	3.57	0.83	9.53	22.82	
	(39.0)	(15.6)	(3.6)	(41.8)	(100)	0.4
11	923.15	229.86	60.09	638.18	1851.27	
	(49.9)	(12.4)	(3.2)	(34.5)	(100)	32.0
Total	1931.42	995.88	254.94	2597.73	5779.97	
	(33.4)	(17.2)	(4.5)	(44.9)	(100)	100

* Except the last column each figure in the ( ) shows the percentage of national output by each industry by region. The figures in the ( ) in the last row are the regional shares of total national industrial output by each region.

Sensitivity Analysis

The previous study shows that the demand pattern for input varies among alternative project types. Due to the differences of each regional trade pattern, the regional demand patterns of the same project is also expected to vary when a project region is altered. The evaluation of each sector multiplier in the previous section has shown that multipliers for the same industry varied among alternative regions. The natural conclusion is that the project impact on regional and national economies will not be the same for alternative project types with the size of investment and project region held constant. And the impact from the same project is not the same if the project region is altered. In this section the sensitivity of the project impact is evaluated in terms of output and income resulting from a hypothetical investment of $1,000 for 12 different types of water resource projects in alternative project regions. The evaluation is based on the closed I/O model, and is limited to the contract cost for various water resource projects. The contract cost is used because no information is available for the part of non-contract costs for different water resource projects. Again, the ten sector model is used for the analysis. The demand patterns for input per $1,000 contract cost for the ten sector model is already investigated in Table 12. According to this distribution pattern, the most labor intensive project is dredging (household income $553) and the most capital intensive project is powerhouse ($201) according to the proportion of direct attribution of project contract cost to household income.

Since the regional contributions to the total economic impact of a project on the national economy by industrial sector are partially investigated in the evaluation of MKARMPP, the sensitivity is limited for the changes in total industrial output and the resulting national income as a whole. This national impact is the sum of the entire feedback impact for the nation as a whole, regardless of project region.

The estimated output and income, resulting from various $1,000 water resource projects in different regions, are shown in Table 17. The estimated level of income is shown in parentheses.

(1) Sensitivity in terms of level of output

The range of the estimated level of output per $1,000 contract cost among types of projects constructed in Region I, ranges from $5329 (Revetment) to $5860 (Dredging) and the difference is about $530. The same ranges among different project types invested in other regions are: $559, $528, and $589 in Regions II, III, and IV respectively. However, the ranges of output resulting from the same project type invested in alternative regions show that powerhouse is lowest ($226), and that levees are highest ($334). Therefore, the variation of output resulting from the investment of the same project in different regions is generally smaller than that among different project types invested in the same region. It is interesting to note that the level of output is the highest resulting from the

TABLE 17

SENSITIVITY OF IMPACTS BY PROJECT TYPE AND REGION

Project Type/Region	Region I	Region II	Region III	Region IV
1. Multipurpose project including power	5808.41 (1849.96)	5509.32 (1745.31)	5791.51 (1833.23)	5713.28 (1817.08)
2. Dredge	5860.71 (1892.74)	5557.62 (1787.72)	5858.08 (1880.73)	5787.62 (1868.70)
3. Large Earth Fill Dam	5816.61 (1832.97)	5505.03 (1724.19)	5803.93 (1817.19)	5732.63 (1804.57)
4. Small Earth Fill Dam	5756.57 (1764.08)	5453.01 (1658.01)	5749.43 (1750.63)	5673.03 (1735.78)
5. Local Flood Protection	5798.86 (1857.55)	5486.62 (1748.12)	5779.02 (1839.61)	5700.29 (1823.41)
6. Pile Dikes	5650.84 (1781.84)	5325.43 (1667.81)	5645.33 (1769.87)	5549.39 (1746.75)
7. Levees	5771.06 (1908.42)	5437.55 (1792.08)	5761.11 (1894.21)	5676.27 (1876.05)
8. Revetment	5329.35 (1557.03)	4998.68 (1439.21)	5330.90 (1548.95)	5198.72 (1509.79)
9. Powerhouse	5766.01 (1611.03)	5540.14 (1531.92)	5762.21 (1599.31)	5691.85 (1585.52)
10. Medium Concrete Dam	5848.40 (1848.35)	5548.66 (1743.19)	5823.61 (1828.44)	5750.16 (1814.39)
11. Lock & Concrete Dam	5696.50 (1665.00)	5424.27 (1569.03)	5682.71 (1649.88)	5598.46 (1630.59)
12. Miscellaneous	5752.85 (1762.19)	5450.04 (1656.73)	5753.13 (1751.45)	5676.44 (1736.76)

Note: the first row of each project type shows the total amount of output due to $1,000 contract cost investment for each region. The numbers in parenthesis under the output show the total amount of income due to the investment.

investment in the Impact Region for almost all types of investment and it is least when the project is constructed in Region II.

(2) Sensitivity in terms of income

The estimated level of income generated per $1,000 contract cost among types of projects constructed in the Impact Region ranges from $1557 (Revetment) to $1908 (Levees), and the range is $351. The same ranges resulting from the same investment in other regions are $353, $346, $367 in Regions II, III, and IV respectively. The range of impact variation among regions for the same project type shows that the lowest range is for Powerhouse ($80) and the highest is for Dredging or Lock and Concrete Dams ($105). As in the case of type I multipliers, the impact variation among project types is much greater than that among regions for the same project type. The estimated income when the project is invested in the Impact Region is greatest followed by Regions III, IV, and II in that order. It is also noted that the highest income generator is in labor intensive projects such as dredging and levees, and the lowest income generator is in capital intensive projects such as revetment and powerhouse.

In the impact analysis, it has been shown that the greater the degree of economic self-reliance by a region, the greater is the share of regional final demand, and even greater is the share of output and income if the shares are compared to those of regional final demands. However, in the sensitivity analysis the level of national output and income generated by the same project in alternative regions does vary, but not significantly compared to that caused by different project types invested in the same region. This means that the national impact of a project is not related to the size or openness of the economic structure of a project region.

The Impact of MKARMPP Through an 80 Sector Model

Up to this point the evaluation of the MKARMPP and the sensitivity analysis has been conducted through the 10 sector I/O model except in the analysis of demand patterns of investment expenditures on the nation and each IRIO Region. As in the impact evaluation of the MKARMPP through a 10 sector I/O model, the impact per $1,000 contract cost and project cost through an 80 sector model, is evaluated.

(1) Evaluation of the Project Impact Based on Contract Cost

The output and income resulting from the MKARMPP contract cost is shown in Table 18. The output per $1,000 contract cost is estimated to be approximately $5797, of which Regions I, II, III, and IV share about 33.1; 17.0; 4.8 and 45.1 percent respectively. The income (Sector 80) is estimated

Table 18
Output Resulting from McClellan-Kerr Arkansas River
Multiple Purpose Project Contract Cost
Per $1000 - 1963 Prices

I/O Sector	Region I	Region II	Region III	Region IV	Nation	% Shares	% Shares by Aggregated Sector
1	7.55	13.48	9.14	69.47	99.64	1.72	
2	3.35	18.87	7.31	54.83	84.36	1.46	
3	1.59	1.19	.13	3.31	6.23	.11	
4	.90	1.77	.44	3.42	6.54	.11	3.40 (1)
5	.00	.18	.22	6.42	6.82	.12	
6	.04	.32	.03	3.01	3.40	.06	
7	.29	.06	.50	7.66	8.51	.15	
8	3.65	39.80	2.03	10.23	55.71	.96	
9	49.80	35.66	8.56	6.32	100.35	1.73	
10	.02	.34	.02	.73	1.10	.02	3.04 (2)
11	0.00	0.00	0.00	0.00	0.00	0.00	
12	23.03	10.49	2.55	23.01	59.08	1.02	1.02 (3)
13	.07	.11	.02	.64	.84	.01	
14	44.42	79.25	28.02	162.53	314.22	5.42	
15	0.00	.18	.08	32.97	33.23	.57	
16	.38	1.60	.13	46.29	48.40	.83	
17	.10	1.93	.14	9.89	12.05	.21	
18	4.92	8.01	2.77	64.20	79.91	1.38	
19	.18	1.03	.50	10.74	12.45	.21	
20	5.62	9.85	.21	15.39	31.06	.54	
21	.04	.15	.03	.92	1.13	.02	
22	1.11	2.16	.75	11.37	15.38	.27	
23	.04	.13	.04	.69	.91	.02	
24	.91	5.71	1.56	33.29	41.47	.72	
25	.40	1.59	1.34	13.57	16.89	.29	
26	4.33	5.99	1.29	17.92	29.53	.51	
27	1.04	17.35	1.85	28.32	48.56	.84	
28	.03	2.95	.23	14.89	18.10	.31	
29	.37	2.55	6.34	27.73	37.00	.64	
30	.11	.84	.59	5.32	6.86	.12	
31	26.22	44.00	3.85	25.66	99.73	1.72	
32	.87	5.59	2.05	31.91	40.42	.70	
33	0.00	.05	.05	3.85	3.94	.07	
34	.63	1.34	2.02	11.84	15.83	.27	15.67 (4)
35	.85	.78	.22	7.02	8.86	.15	
36	22.55	38.16	9.26	20.45	90.43	1.56	
37	3.10	12.02	4.84	114.35	134.32	2.32	
38	1.63	3.03	.48	32.11	37.25	.64	
39	.15	1.61	.49	6.35	8.60	.15	
40	24.61	17.01	3.73	11.09	56.44	.97	
41	.21	1.02	.57	13.38	15.18	.26	
42	2.17	6.33	1.04	22.23	31.77	.55	
43	3.00	1.16	.12	20.46	24.74	.43	
44	.01	.08	.04	1.04	1.17	.02	
45	10.46	30.64	1.28	33.90	76.28	1.32	
46	.32	5.78	.13	9.17	15.41	.27	
47	.16	.29	.24	9.42	10.11	.17	
48	.02	.16	.03	1.58	1.80	.03	
49	1.78	1.39	.32	12.10	15.59	.27	
50	.26	.92	.36	9.22	10.76	.19	
51	.19	.12	.01	1.27	1.59	.03	
52	1.64	1.10	.19	2.76	5.70	.10	
53	2.24	1.79	1.41	24.09	29.53	.51	
54	2.65	.20	.28	12.72	15.85	.27	
55	.73	1.22	.48	6.99	9.42	.16	
56	1.56	1.51	.24	8.77	12.09	.21	
57	.23	.15	.07	5.53	5.98	.10	
58	.12	.52	.30	5.03	5.97	.10	
59	.80	14.13	31.67	84.38	130.98	2.26	
60	.30	.38	.09	.90	1.66	.03	
61	1.05	2.75	1.42	7.82	13.05	.23	
62	1.25	.74	.08	4.50	6.57	.11	
63	.16	.11	.07	5.17	5.51	.10	
64	1.56	2.50	.26	18.93	23.25	.40	13.90 (5)
65	102.10	22.65	6.31	58.96	190.03	3.28	
66	21.02	7.36	2.00	20.06	50.44	.87	
67	.04	.01	.00	.03	.07	.00	
68	60.95	23.56	5.64	49.09	139.23	2.40	6.55 (6)
69	286.63	67.08	19.95	189.11	562.77	9.71	9.71 (7)
70	32.77	47.85	5.62	64.66	150.91	2.60	
71	148.41	54.49	14.69	137.11	354.70	6.12	8.72 (8)
72	31.08	9.42	2.39	24.44	67.14	1.16	
73	11.90	23.76	5.03	77.38	118.07	2.04	
74	0.00	0.00	0.00	0.00	0.00	0.00	
75	27.54	7.16	2.18	17.59	54.47	.94	
76	11.49	3.27	.97	10.48	26.21	.45	
77	70.58	19.76	5.36	52.12	147.82	2.55	7.14 (9)
78	5.69	2.99	.70	7.62	17.00	.29	
79	2.40	.66	.17	1.59	4.83	.08	.37 (10)
80	841.17	227.17	66.15	633.89	1768.38	30.50	30.50 (11)
Total	1921.52	979.16	281.71	2615.19	5797.59	100.00	100.00
% Share	(33.14)	(16.89)	(4.86)	(45.11)	(100.00)		

to be $1768, of which 47.5; 12.8; 3.7 and 35.8 percent are shared by Regions I, II, III, and IV respectively. The income and output are estimated to increase by $92 and $28 respectively when the impacts are evaluated through the 80 sector I/O model compared to those estimated through the 10 sector model. The increase is insignificant and is equivalent to 1.6 percent of the values obtained through the 10 sector model. However, the distribution of output and income among regions is altered in favor of the project region (about 3 percent) at the expense of other regions. This is reasonable if one considers that the regional final demand on the Impact Region through the 80 sector model is about 3 percent greater than the result of the 10 sector model.

The distribution of output by a disaggregated industry sector shows that heavy demand falls in the following order excluding the household sector: wholesale and retail trade; real estate and rental; food and kindred products; transportation and warehousing; automobile and repair services; utilities; and motor vehicles and equipment. However, if the output by 80 sectors is aggregated into 10 sectors the demand pattern is the same as that based on the 10 sector model. The rank of output demand will be: durable and non-durable manufacturing; trade, finance, insurance and real estate services; and transportation and utilities, in that order.

(2) Evaluation of the Project Impact Based on Project Cost

The output and income which is estimated through the disaggregated I/O model is shown in Table 19. The total output and income per $1000 project cost are estimated to increase by about $110 and $30 respectively or less than 2 percent from those estimated through the aggregated model. The share of output and income by the Impact Region has increased by less than 3 percent. The distribution pattern of industrial output is generally the same as in the 10 sector model. Since the total project cost is approximately $1,094,808,000, the estimated total project impact of the MKARMPP on the nation is: $6,448,944,627 in terms of output and $2,059,476,173 in terms of household income in 1963 dollars. The distribution of output for each region is 35.8; 16; 4.7; and 43.4 percent for Regions I, II, III, and IV respectively. The distribution of household income by each region is 52.2; 11.5; 3.4; and 32.8 percent respectively.

The industrial output of each sector is the joint product of the distribution pattern of final demand and each sector multiplier. Since we have not made the comparison of two sets of sector multipliers from the 10 and 80 sector model, it is difficult to conclude whether each sector multiplier, derived from the two models, may be similar or not.[6] However, the insignificant differences of the total output and income and distribution pattern of output by industry derived by two different I/O models suggests that the difference between the two sets of multipliers is not significant. This conclusion further suggests that an aggregated I/O model could be used in an impact analysis if detailed information from a highly disaggregated industrial level is not mandatory. This is especially true under the constraints of time, resources, and data.

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[6] See Richardson op. cit., pp. 135-38, for a further discussion about the difference between sector multipliers derived from aggregated and disaggregated I/O models.

Table 19
Output Resulting from McClellan-Kerr Arkansas River
Multiple Purpose Project Cost
Per $1000 - 1963 Prices

I/O Sector	Region I	Region II	Region III	Region IV	Nation	% Shares	% Shares by Aggregated Sector
1	8.45	14.72	9.78	72.97	105.92	1.80	
2	3.77	20.74	7.84	57.32	89.67	1.52	
3	1.71	1.13	.14	3.28	6.25	.11	
4	.99	1.93	.47	3.56	6.94	.12	3.55 (1)
5	.00	.15	.18	5.59	5.92	.10	
6	.04	.28	.03	2.72	3.07	.05	
7	.27	.05	.46	7.02	7.80	.13	
8	3.70	39.37	2.01	9.98	55.07	.93	
9	40.03	28.71	6.90	5.37	81.02	1.38	
10	.02	.33	.02	.71	1.08	.02	2.61 (2)
11	0.00	0.00	0.00	0.00	0.00	0.00	
12	24.84	10.13	2.52	22.45	59.95	1.02	1.02 (3)
13	.09	.12	.02	.66	.89	.02	
14	51.19	86.30	30.19	165.71	333.39	5.66	
15	0.00	.19	.08	35.21	35.48	.60	
16	.44	1.76	.14	48.81	51.14	.87	
17	.11	2.08	.15	10.12	12.45	.21	
18	5.70	8.92	2.93	67.21	84.76	1.44	
19	.21	1.11	.54	11.30	13.16	.22	
20	4.87	8.69	.21	14.82	28.59	.49	
21	.04	.16	.03	.94	1.16	.02	
22	1.24	2.41	.84	11.89	16.38	.28	
23	.04	.13	.04	.69	.91	.02	
24	.96	5.92	1.66	33.86	42.41	.72	
25	.41	1.63	1.40	13.83	17.28	.29	
26	4.91	6.38	1.31	18.23	30.83	.52	
27	.96	16.56	1.82	27.91	47.25	.80	
28	.03	2.94	.23	15.02	18.22	.31	
29	.43	2.73	7.10	29.15	39.41	.67	
30	.11	.81	.58	5.20	6.70	.11	
31	25.93	43.07	3.79	25.03	97.82	1.66	
32	.84	5.32	1.99	31.08	39.23	.67	
33	0.00	.05	.05	4.08	4.18	.07	
34	.72	1.51	2.18	12.45	16.85	.29	15.93 (4)
35	.88	.81	.23	7.15	9.06	.15	
36	18.25	30.98	7.55	17.11	73.90	1.25	
37	2.52	10.02	4.03	99.37	115.95	1.97	
38	1.40	2.68	.44	29.02	33.54	.57	
39	.16	1.72	.52	6.56	8.97	.15	
40	19.89	13.79	3.03	9.20	45.91	.78	
41	.20	.96	.56	12.90	14.62	.25	
42	1.93	5.70	.98	20.90	29.51	.50	
43	2.43	.96	.10	16.88	20.38	.35	
44	.01	.09	.04	1.09	1.23	.02	
45	8.40	24.62	1.03	27.30	61.35	1.04	
46	.26	4.66	.11	7.44	12.46	.21	
47	.14	.26	.23	8.36	8.99	.15	
48	.01	.15	.03	1.54	1.74	.03	
49	1.45	1.15	.28	10.25	13.13	.22	
50	.22	.79	.33	7.96	9.29	.16	
51	.17	.11	.01	1.18	1.47	.02	
52	1.65	1.09	.19	2.74	5.68	.10	
53	1.82	1.47	1.17	20.17	24.63	.42	
54	3.05	.21	.29	13.38	16.93	.29	
55	.65	1.09	.44	6.45	8.62	.15	
56	1.76	1.64	.26	9.02	12.68	.22	
57	.26	.16	.07	5.66	6.15	.10	
58	.13	.54	.31	5.02	6.01	.10	
59	.87	15.01	33.86	85.95	135.69	2.30	
60	.28	.36	.08	.87	1.60	.03	
61	.95	2.52	1.30	7.25	12.02	.20	
62	1.28	.75	.08	4.47	6.58	.11	
63	.19	.11	.07	5.41	5.78	.10	
64	1.76	2.78	.26	19.69	24.49	.42	12.36 (5)
65	92.25	21.64	6.25	57.15	177.29	3.01	
66	22.96	7.12	1.98	19.55	51.61	.88	
67	.04	.01	.00	.03	.08	.00	
68	67.27	22.26	5.44	47.44	142.41	2.42	6.31 (6)
69	302.92	64.28	19.76	184.42	571.37	9.70	9.70 (7)
70	35.42	49.53	5.55	63.84	154.34	2.62	
71	167.98	52.66	14.55	133.99	369.17	6.27	8.89 (8)
72	36.04	8.84	2.36	23.80	71.04	1.21	
73	12.73	24.28	5.13	77.78	119.91	2.04	
74	0.00	0.00	0.00	0.00	0.00	0.00	
75	29.42	6.86	2.17	17.19	55.64	.94	
76	13.36	3.13	.96	10.20	27.65	.47	
77	81.84	18.94	5.29	50.76	156.82	2.66	7.35 (9)
78	6.31	2.97	.70	7.51	17.48	.30	
79	2.63	.63	.17	1.55	4.97	.08	0.38 (10)
80	982.10	217.03	65.13	616.87	1881.13	31.94	31.94 (11)
Total	2109.29	943.67	280.93	2556.58	5890.48	100.00	100.00
% Share	(35.81)	(16.02)	(4.77)	(43.40)	(100.00)		

Chapter V

Summary and Conclusion

Summary of the Study

The historical origin of federally financed water resources development projects in the Arkansas River Basin goes back to as early as the end of the 19th century. The massive investment in this region is identified as the "McClellan-Kerr Arkansas River Multiple Purpose Project." This is one of the biggest and longest federal construction projects in water resources development investments. For this impact study the project defined here is the investment in this river basin area during the fiscal years of 1857 to 1971. The objective of the project is to control floods, supply water and electric power, and to improve the navigation along the Arkansas River up to Tulsa, Oklahoma, with an investment cost of approximately 1.1 billion in 1963 dollars.

To evaluate the construction impact of the investment expenditures of this federal project on regional and national economies, an interregional I/O model (fixed column coefficient variety) with four internal regions and 79 industrial sectors in each region (IRIO) has been adopted. The four internal regions are: the Impact Region (Region I, consisting of part of the states of Arkansas and Oklahoma along the Arkansas River); the Southern Region (Region II, consisting of the states of Texas and Louisiana and the remaining parts of the states of Oklahoma and Arkansas after deducting the parts included in the Impact Region); and the Northern Region (Region III, consisting of the states of Kansas and Missouri) and the Rest of the United States (Region IV consisting of the rest of the United States not included in Regions I, II, and III). The division of the internal regions is based on the major trading relationships of the Impact Region with other regions during 1963.

The basic data sources for the IRIO are from the multiregional (51 U.S. states) I/O study for the year 1963 by the Harvard Economic Research Project (MRIO) for the Economic Development Administration and Trade Flow Analysis for the same year of 44 U.S. regions by the Jack Faucett Associates for the Harvard Study.

To construct the IRIO from MRIO data, first the I/O tables for each pair of substates (one for the part of the Impact Region and the other for part of Region II) of the states of Arkansas and Oklahoma and the trade flows associated with these substates and other regions are estimated from their original state's I/O tables and their trade with other regions in the MRIO. To estimate the substates' I/O tables and their trade patterns the following assumptions are made: 1) the production function of each substate is the same as that of the state for each industry and 2) each substates' share of state export and import for each industry is proportional to its share of state output and requirements respectively. To estimate substate output and requirements for each industry, the estimates

of county output, personal income and various census data for each state were utilized. Having estimated substate I/O tables and their trade flows, I/O tables and trade flows for each region of IRIO are estimated by aggregating I/O data of states or substates which will be included in each IRIO region. From the I/O table of IRIO the regional technical coefficients (A), trade coefficients (T), and interregional direct requirements table (TA) are estimated.

Both open and closed I/O models are evaluated. To close the I/O model, household column and row coefficients are estimated. Household column coefficients are estimated from the consumption expenditure pattern in the IRIO I/O table, and household row coefficients are estimated from value added in the same table multiplied by the national ratio of household income to value added for each industrial sector.

To construct the final demand vectors for the impact study through an I/O model, the MKARMPP cost is converted into 1963 dollars and further classified into contract cost and non-contract cost. The investment costs are distributed among various industrial sectors applying the demand patterns for input by 12 different types of water resources investments. The demand patterns for input for various types of water resources development projects were originally developed by the Bureau of Labor Statistics and Resources For the Future, Inc. for the year 1958 and are deflated for 1963 by this author.

According to these demand patterns, demand for input of a water resources project varies among types of projects. The most capital intensive project is powerhouse construction and the most labor intensive project is a levee. However, the general characteristics of the demand pattern for input for water resources projects, as a whole, shows a relatively heavy demand for on-site labor and manufacturing goods, especially equipment, followed by a considerable demand for mining products and transportation requirements. The MKARMPP consists of four different types of projects: multiple purpose project (48 percent), locks and dams (37 percent), revetments (11 percent) and flood control (4 percent).

Because no region is completely a self-contained economy and because of the differences in trade patterns among regions, the delivery of input which is required for any project must have originated from various regions according to the demand pattern of project inputs and trade patterns of the project region to be selected. The total demand for the input of an investment project is defined as the national final demand. The regional share, which will be produced and delivered by a region to the project region is defined as the regional final demand. The demand pattern of the MKARMPP shows that the single largest demand for input is labor (50.7 percent); followed by manufacturing goods (29 percent); stone, clay mining products (7.2 percent); trade and services (6.2 percent); and transportation and communications (5.3 percent). Of this national final demand the project region (Region 1) shares about 73 percent of its demand in the 80

sector model. All requirements for labor; stone and clay; transportation and communication; and local repair services are met by the project region, but less than 20 percent of the manufacturing goods are supplied within the project region. This proportion is slightly understated in the 10 sector model due to the overstatement of the trade pattern of the aggregated industrial sector. The share of demand for input by industrial sector and their regional share may be further modified when the project cost is replaced by the contract cost.

For the convenience of analysis of the economic impact of any given type of investment (water or non-water resources project) in any region with the IRIO Type I and Type II multipliers by aggregated industrial sector for both output and income are evaluated. The Type I multiplier is derived from the open model and is suited for evaluating the direct and indirect impact of a given investment, while the Type II multiplier is derived from the closed model and shows the added induced impact resulting from the spending of the household income which is earned during the production process. These multipliers are derived from the manipulation of the interregional direct and indirect table $(I-TA)^{-1}$ and interregional direct, indirect, and induced requirements table $(I-T_H A_H)^{-1}$ respectively. These tables themselves consist of matrices of the interindustry and interregional multipliers for the delivery of a dollar's worth of each industrial output to the final users.

The output multiplier is suited for evaluating interindustry linkages and size of transaction per one dollar's change in final demand, while the income multiplier is suited for evaluating the magnitude of income changes induced by a dollar's change in household income. Type I output multiplier by industry in Region I ranges from the lowest 1.35 (finance, insurance and real estate combined) to the highest 2.25 (trade). Agriculture, forestry and fishery combined, construction and durable manufacturing sectors show relatively higher multipliers.

Type II output multipliers for the same region by industry sector ranges from the lowest 3.76 (finance, insurance and real estate) to the highest 6.55 (government enterprises). The ranking order of the Type II multipliers has significantly changed from that of the Type I multipliers. The induced impact of multipliers is significant with government enterprises; trade; service and transportation; communication; and utility sectors. These multipliers have increased more than 3.5 times their Type I counterparts. The variation of multipliers for the same industry among different regions is minor, particularly in Type I multipliers.

Type I income multipliers, in Region I range from the lowest 1.23 (trade) to the highest 3.04 (non-durable manufacturing) and the order of ranking of the size of multiplier is very similar to that of the Type I output multiplier. However, unlike the Type II output multiplier the induced impact on each industrial sector is fairly uniform. The Type II multiplier has risen by little more than twice its Type I counterpart, and it ranges from 2.82 to 6.76. The order of ranking the Type II income multipliers

is the same as that of the Type I multiplier. Except for agriculture, forestry and fishery and non-durable and construction sectors, the variation of Type I and II multipliers among regions is insignificant.

The direct, indirect, and induced impact of the MKARMPP is evaluated for both contract and project cost through the 10 sector model. The impact based on contract cost constitutes only a partial impact of the total project cost. The total impact of the MKARMPP contract cost on the national economy is estimated to be approximately \$5 billion in terms of output and \$1.5 billion in terms of household income. The impact per \$1,000 MKARMPP project cost is estimated to bring \$5780 of output or \$1851 income on the national economy. The total impact of the MKARMPP cost on the national economy is estimated to be approximately \$6.3 billion output or \$2.0 billion income in 1963 prices. The heavier impact of output was estimated to fall on the manufacturing industry followed by trade, finance, insurance and real estate services and the transportation and communication sectors. The project region is estimated to share approximately 33.4 percent of output and 50 percent of income regardless of its high share of regional final demand (70 percent). The regional share of national output increases when the regional economic structure tends to be more self-contained. The share of the Rest of the U.S. for the national output increases to 54 percent despite its low share of regional final demand (15 percent). The total household income shared by each region is estimated to be 50 percent, 12 percent, 3.2 percent and 34 percent by Regions I, II, III, and IV respectively.

The project impact is also evaluated with an 80 industrial sector model for the benefit of getting a more detailed industrial classification. However, the level and pattern of output by industry has not changed significantly from those obtained through the 10 sector model. However, the regional share of output and income have slightly changed in favor of the project region due to the disproportionate changes in final demand and the trade flows of each industrial sector from those in the 10 sector model. The total national impact is \$2.06 billion dollars in household income and the share of each region is: 52.2, 11.5, 3.4, and 32.8 percent for Regions I, II, III, and IV respectively.

A sensitivity analysis of the project impact of 12 different types of water resources development investments in terms of output and income on the national economy has been evaluated through the 10 sector model based on per \$1,000 project contract costs. The impact of investment resulting from investing alternative types of water resources projects in the same region or from the same type of investment project in alternative regions do vary for both the level of output and income. The variation of output is greater than that of income, and the regional variation is much less than those from different types of investments in the same region for both output and income. The highest output generator from alternative project types is dredging (\$5860) and the lowest one is revetment (\$5329) and the highest income generator is also dredging (\$1892) and the lowest one is revetment (\$1557). The labor intensive project generally brings relatively

higher output and income and conversely, the capital intensive project brings relatively lower output and income. The study shows also that, generally, the highest level of output and income are from the investment in Region I for most types of investment and the lowest output and income is from the same investment in Region II.

Limitation of the Study

The impact of the MKARMPP in this study is limited to the impact of construction expenditures for the specific types of water resources investment projects. However, the project impact may be extended beyond the construction phase. It may be extended to the environmental impact study or be further extended to include structural changes in the local economy due to the contribution of the output of the MKARMPP on the local economy. These are beyond the scope of this study.

The impact of MKARMPP is also evaluated through a fixed column coefficient interregional I/O model with 1963 regional production functions and trade patterns estimated in MRIO, and with fixed regional interindustry and interregional structural relationships estimated in IRIO under perfectly elastic supply conditions. Any significant changes in the structural relationships within the IRIO framework may become sources of bias for the impact analysis.

Conclusion of the Study

The construction impact of the MKARMPP ($1.1 billion) on the national economy is estimated to increase approximately $6.4 billion in terms of output or $2.1 billion in household income in 1963 prices. Of this amount approximately 35.8 percent of output and 52 percent of income are estimated to be shared by the project region. The study shows that the economic impact of a project, regardless of the project type, on local and national economies depends upon multiple factors:

(1) the size and demand pattern of a project expenditure;
(2) the way in which the regions are organized;
(3) the economic structure of each region (the production and trade patterns);
(4) the consumption pattern of each region; and finally,
(5) the project region to be selected.

The assessment of the construction impact of the MKARMPP is basically short-term. The true impact of the investment must be the long-term economic development of the Arkansas River Basin Area induced by the main output of the investment. The main output of the investment are improvement of the water transportation system; supply of water and electric power; and recreation sites and flood control for the region.

The assessment of the long-term economic impact is beyond the scope of this research objective.

AN APPLICATION OF THE INTERREGIONAL I/O MODEL FOR THE STUDY OF THE IMPACT OF THE McCLELLAN-KERR ARKANSAS RIVER MULTIPLE PURPOSE PROJECT

DATA APPENDICES

APPENDIX A

Procedures

for

The Construction of the Interregional I/O Model for Potential Use in the McClellan-Kerr Arkansas River Multiple Purpose Project Impact Study

CONTENTS

I. INTRODUCTION

This is part of a continuous series of reports associated with a study for the Evaluation of Interregional Input-Output Models for Potential Use in the McClellan-Kerr Arkansas River Multiple Purpose Project Impact Study (MKARMPPIS). In the previous reports,[1] an interregional I/O model with thirty (30) industrial sectors and five (5) regions had been recommended for construction for the impact study (IRIO). The sequences for the construction of the recommended model consisted of three phases:

Phase 1 - Construction of regional I/O tables and interregional trade flows based on 1963 data. These sets of data provide basic information needed to obtain technical and trade coefficients of the recommended I/O model; and these coefficients, together with given project investment expenditures as final demands, are the necessary information to determine both the direct and the indirect impact of the project on the U.S. economy. Maximum utilization of the existing data developed for the multiregional I/O model for the United States (MRIO),[2] adjusted by the Bureau of Economic Analysis[3] was suggested for the construction of the recommended model. These data were based on 1963 statistics and are considered appropriate for the evaluation of projects constructed before 1970.

Phase 2 - Construction of econometric submodels to measure the project impact resulting from the increase in consumption and production capacity induced by the expansion of the economy resulting from project expenditures.

Phase 3 - Updating the input-output model for the evaluation of project expenditures for the period of 1970-1980.

The purpose of this report is to outline through the use of MRIO data, basic methodologies and certain results of the work related to the Phase 1 operation in the construction of the IRIO. This report includes an explanation of the basic data sets in the MRIO and the methodologies used in applying these data to the IRIO followed by a brief introduction of the IRIO model. Finally, the conceptual procedures and equations to solve this model will be introduced.

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1 Ungsoo Kim, "Research Report for Evaluation of Interregional Input-Output Models for Potential Use in the McClellan-Kerr Arkansas River Multiple Purpose Project Impact Study," Contract No. DACW 31-72-C-0059, Phase I & II, submitted to the Institute for Water Resources, U.S. Army Corps of Engineers, 1972.

2 U.S. Department of Commerce, Economic Development Administration, A Multiregional Input-Output Model for the United States, prepared by Karen R. Polenske, December, 1970.

3 U.S. Department of Commerce. Implementation of the MRIO Model, prepared by the Bureau of Economic Analysis for the Economic Development Agency, Springfield, Virginia: The National Technical Information Center, 1973.

II. BRIEF CHARACTERISTICS OF THE IRIO

The construction of an interregional I/O model for the MKARMPPIS (IRIO) had been recommended at the end of 1972 after a review of the basic objectives of the impact study and various theoretical and empirical studies related to I/O analysis. The recommended model is a column coefficient model[4] consisting of five internal regions, within national boundaries, having less than 30 industrial sectors. The five internal regions are: (1) the Impact Region containing parts of the states of Arkansas and Oklahoma; (2) the Southern Region consisting of the states of Texas, Louisiana, and the remainder of Arkansas and Oklahoma less the Impact Region; (3) the Northern Region, which consists of the states of Kansas and Missouri; (4) the Northeastern Region consisting of Indiana and Illinois, and (5) the region representing the remainder of the United States.

An I/O table for each state of the United States with details of 79 industrial sectors and trade flow among 44 regions is available from the study developed for the MRIO. Since the existing information about interindustry and trade flows for the 79 industries serves as a detailed study of the project impact, the same industrial classifications will be used for the IRIO. However, in an attempt to keep the operation of the model simple, the numbers of internal regions will be reduced from five to four by aggregating the Northeastern Region into the rest of the U.S. Since the trade value between the impact region and Northeastern Region consists of only six percent of the total trade of the impact region, the elimination of the Northeastern Region (as an independent region) does not lessen the utility of the recommended I/O model (see Map 1).

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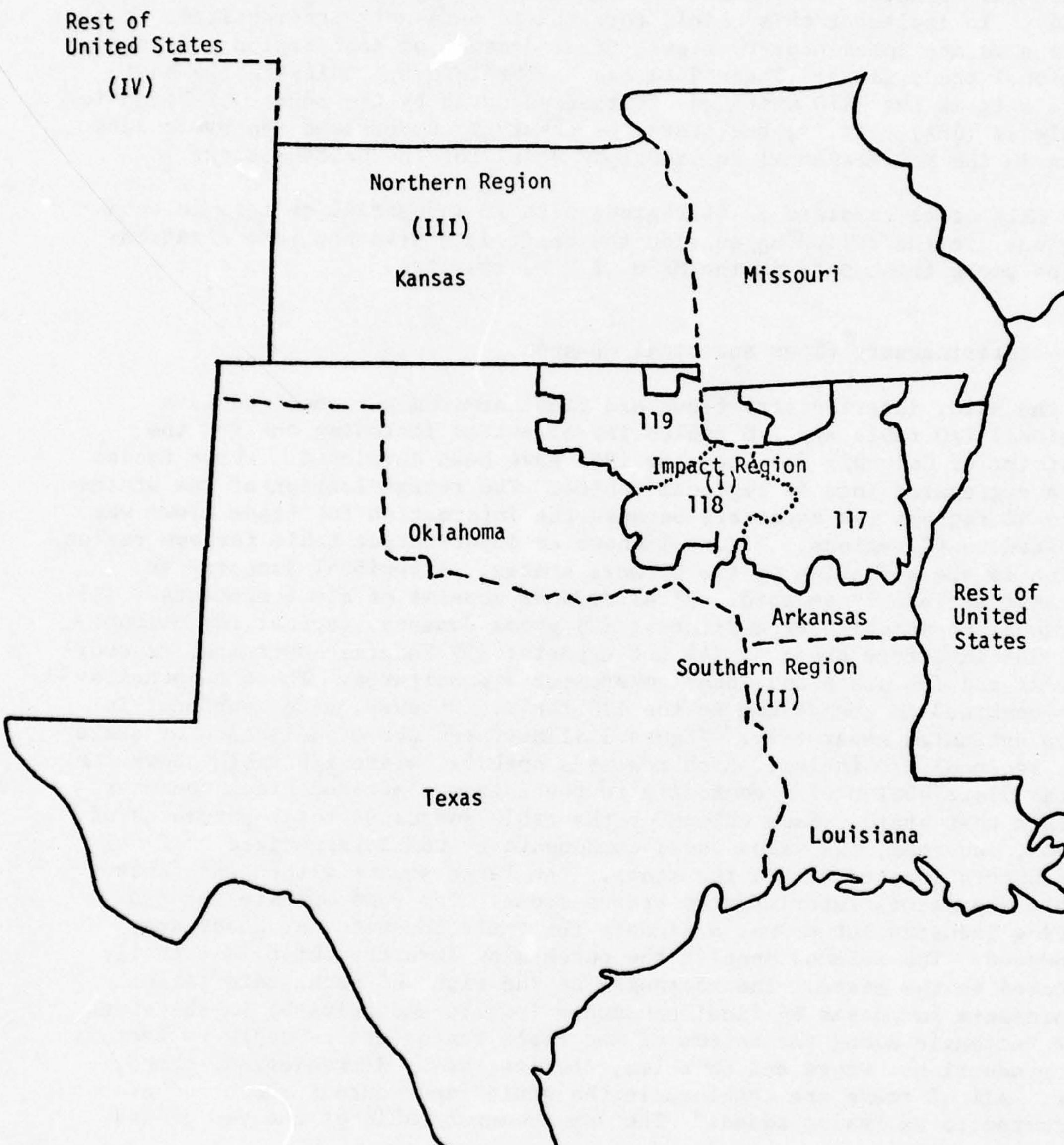
[4] A fixed column coefficient model is defined as an interregional I/O model in which trade coefficients are derived by dividing the receipts of a commodity from a particular region by the total receipts of that commodity by the receiving region, and the coefficients are assumed to be stable over the period of economic analysis.

Map 1
Regional Organization for the IRIO



III. THE BASIC DATA IN THE MRIO

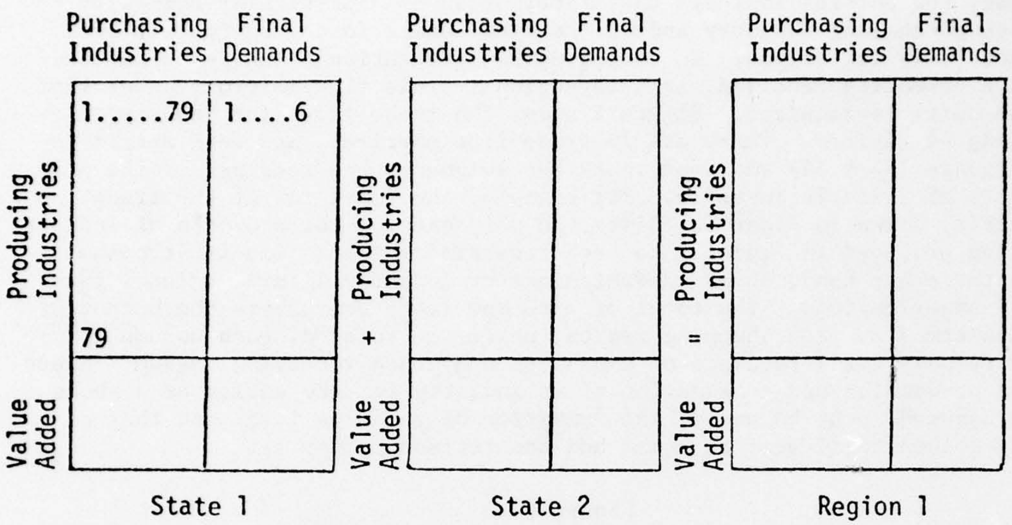
The IRIO model will provide an analytical tool which evaluates the interregional as well as the interindustrial impact of the project upon the U.S. economy. This model is best explained by the use of the following mathematical equation: $X = (I-TA)^{-1}\ TY$. The level of output (X), given the change in project investments (Y), can be projected if the structural relationships of the economy (T&A) are known. T and A are interregional trade and technical coefficients which are the major objectives of this study. To implement this model, three basic data sets are required. These data sets are interindustry flows, final demands of each region and interregional trade flows. These data can be obtained by modifying the basic data sets in the MRIO which was further adjusted by the Bureau of Economic Analysis (BEA). It is, therefore, necessary to understand the basic data sets in the Multiregional Input-Output Model for the United States.

The MRIO model consists of 44 regions with 79 industrial sectors in each region. In the following section the basic data sets and some relationships among these sets in the MRIO will be examined.

(1) Interindustry flows and final demands

In the MRIO, interindustry flows and final demands are combined in a regional I/O table and I/O tables for 51 states including one for the District of Columbia for the year 1963 have been developed. These tables were aggregated into 44 regional tables. The reorganization of the states into 44 regions was necessary because the information for trade flows was limited to 44 regions. Figure 1 shows an input-output table for one region which is the summation of two or more states. A regional industry is classified into 79 sectors. Final demands consist of six components: (1) personal consumption expenditures; (2) gross domestic capital formations; (3) net inventory changes; (4) net exports; (5) Federal Government expenditures; and (6) state and local government expenditures. These components are combined in one column in the I/O table. However, each component is also estimated separately. Figure 1 illustrates the organization of state and regional I/O tables. Each row of a specific state I/O table shows the total distribution of a commodity to the intermediate and final consumers within that state. Each column of the table indicates total purchases of goods, services, and value added components by the intermediate or final purchasers located within the state. The large square within each state table represents interindustry transactions. The rows specify the producing industry but do not designate the state in which the goods are produced. The columns specify the purchasing industry which is actually located in the state. The rectangle at the right of each state table represents purchases by final consumers (public and private) in the state. The rectangle along the bottom of the table represents payments to factors of production: wages and salaries, profits, rent, depreciation, taxes, etc. All of these are combined in the state input-output table and are referred to as "value added." The input-output table of the region was

Figure 1
Input-Output Table for a Region and Its Component States



derived by adding the corresponding value of each cell of the I/O table of the states within the region. The characteristics of the I/O table are the same as that of a state. In the MRIO, only five regions out of 44 are a combination of two or more states and 39 regions are represented by single states.

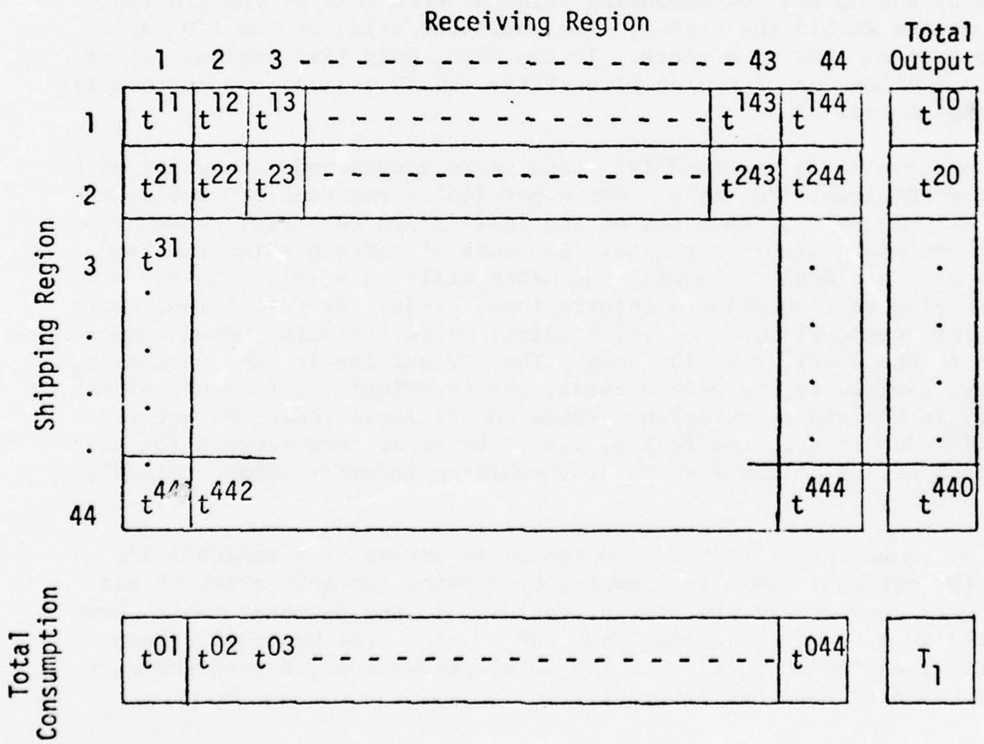
A word of caution is required for those users accustomed to working with a balanced national I/O table. For a particular regional I/O table, the sum of all elements in each row of the table gives the total consumption which takes place within a region. The sums of corresponding rows and columns of a regional table will not necessarily be equal, with the difference being attributable to interregional trade. By definition, there are no interregional flows of value added, hence the value added components pertain to the specific region only. The row entries in each purchasing industry, divided by its column total, are technical coefficients of the industry in the state or region. These coefficients indicate that the production function of the region, i.e., the input requirements for the production of one dollar's worth of purchasing industry output regardless of its origin.

As in the summation of states' I/O tables to arrive at a regional I/O table, the national table is computed by summing the I/O tables of all regions, or summing all the states' tables. In the national table, however, the sums of corresponding rows and columns must be equal, since the total consumption must equal the total production for each industry, i.e., a balanced national I/O table.

(2) Interregional Trade Flows

As shown in the explanation of a regional I/O table in the previous section, row entries indicate the distribution of a particular commodity to each purchasing industry and to the final users in the region without specifying its origin. To complete the information of shipping regions of a commodity received, an interregional trade flow information of that commodity is required. Figure 2 shows the trade flows for industry 1 among 44 regions. There are 79 trade flow matrices, and each matrix is a square (44 x 44) and represents the shipments and receipts of the products of a single industry. For example, the first row of the trade matrix, shown in Figure 2, lists the shipments of the products of Industry 1 and produced in Region 1 to each receiving region. The first column, on the other hand, shows the shipments of Industry 1 into Region 1 from all other regions. The total of each row (t^{go}) represents the output of Industry 1 by each shipping region, while the total of each column (t^{oh}) represents total receipts or consumption by each receiving region. Since the production and consumption of an industry for the nation as a whole is assumed to be balanced, the summation of each row total and that of the column total must be equal and are represented by T_1.

Figure 2
Interregional Trade Flows for Industry 1



(3) Interrelationships between Interindustry and Interregional Trade Flows

Both regional I/O tables and interregional trade flows are important to the completion of the multiregional accounting system. Figure 3 shows the interrelationships between these two sets of data. A clear understanding of these relationships is important in checking the internal consistencies between the two sets of data within the national control totals.

The three relationships shown in Figure 3 are:

1. The relationship between regional and national I/O tables.

2. The relationship between regional production and consumption totals and interregional trade flows.

3. The relationship between the total interregional trade flows and the national I/O table.

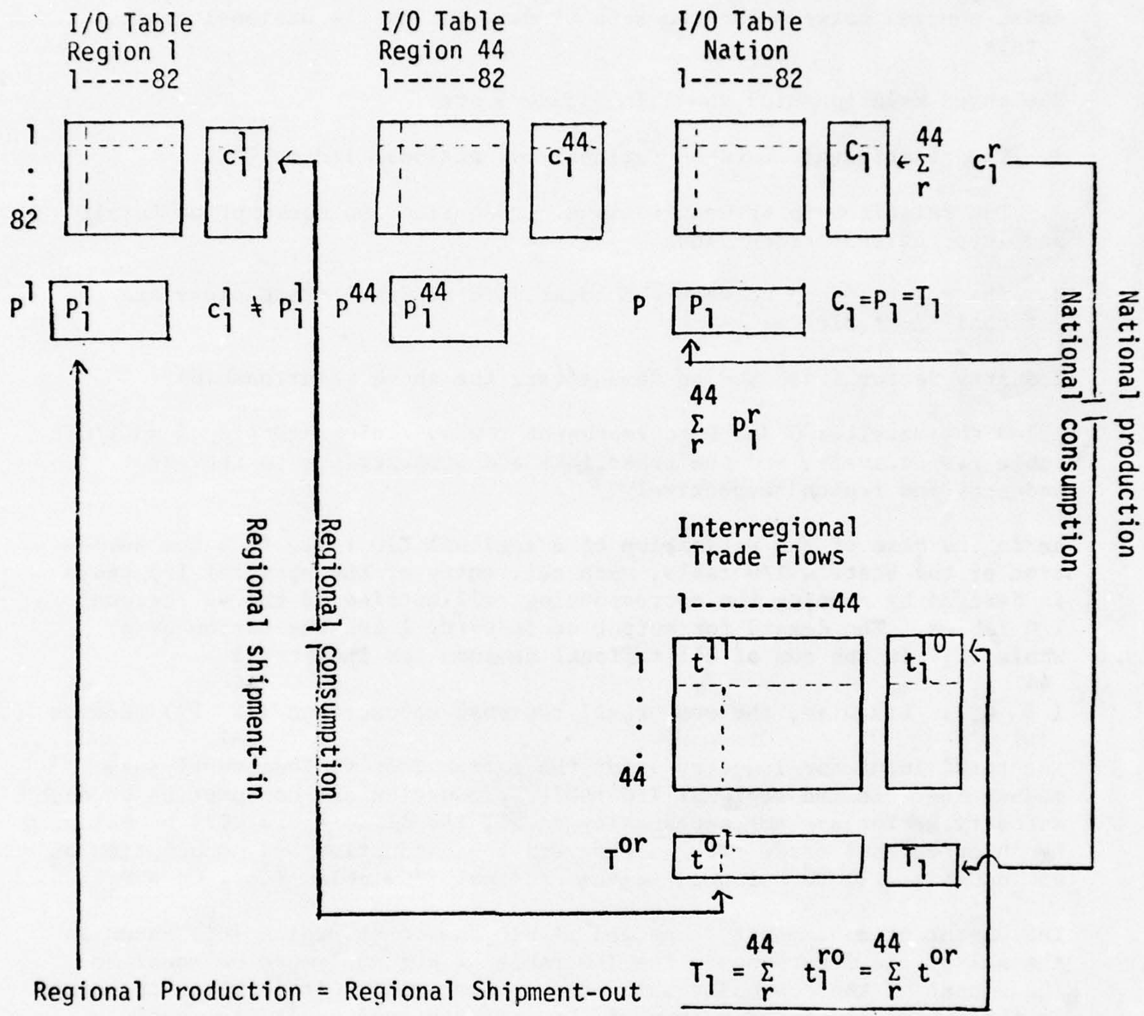
Industry Sector 1 is used to demonstrate the above relationships.

Allow the matrices C and P to represent row and column totals of an I/O table respectively, and the subscripts and superscripts to represent industry and region respectively.

As in the case of the estimation of a regional I/O table from the summation of the state's I/O table, each cell entry of the national I/O table is derived by summing the corresponding cell entries of the 44 regional I/O tables. The demand for output of Industry 1 for the nation as a whole (C_1) is the sum of all regional demands for Industry 1 ($\sum_{i=1}^{44} C_1^i$). Likewise, the sum of all regional productions ($\sum_{i=1}^{44} P_1^i$) becomes the total input for Industry 1 for the nation from various supplying industries. In the regional I/O table, production and consumption of each industry sector are not necessarily equal; the differences will be balanced by interregional trade flows. However, the production and consumption of an industry will be balanced in the national I/O table, i.e., $C_i = P_i$.

The amount of a commodity consumed within the first region (c_1^i) shown as the sum of the first row on the I/O table of Region 1 must be equal to the amount of the commodity shipped into that region (t_1^{01}) which is shown as the sum of the first column of the interregional trade flow table. Note that regional and interregional shipments-in and shipments-out include intraregional shipments and nonshipped production as well as interregional movements of commodities. By the same token, the total amount Industry 1 shipped out of a region, (t_1^{10}) shown as the sum of the first row of the trade flow table, must equal the total amount of the commodity produced in that region, (P_1^1), as shown by the total of the first column in the first region's I/O table.

Figure 3
Relationship Between Regional and
National I/O Tables and Interregional Trade Flows



C&P indicate column & row matrices which include sums of each row and column of national I/O table. A subscript indicates an industry and a superscript indicates a region.

T^{ro} & T^{or} indicate column & row matrices which include the sums of each regional shipments-out and regional shipments-in respectively. T_1 indicates the sum of each regional shipments-out or shipments-in.

The sum of interregional trade flows was made consistent with production and consumption of the nation, and the production and consumption of a commodity is designed to be balanced in the national I/O table. T_1, as shown in the trade flow table, indicates the sum of production of industry 1 by all regions which is equal to the sum of consumption by all regions. Total trade volume of industry (T_1), therefore must equal C_1 or P_1 in the national I/O table.

IV. An Application of MRIO Data for the Construction of IRIO

The basic difference between MRIO and IRIO is that of a division of the United States into a different number of internal regions. The former consists of 44 regions while the latter consists of only four regions. To apply the basic data sets in the MRIO for the construction of IRIO involves some aggregation and disaggregation of the original data. An aggregation of the basic data is required because all regions of the IRIO except the impact region consists of more than two MRIO regions. A disaggregation of the basic data is required because the organization of the impact region in the IRIO requires dividing the MRIO regions of Arkansas and Oklahoma.

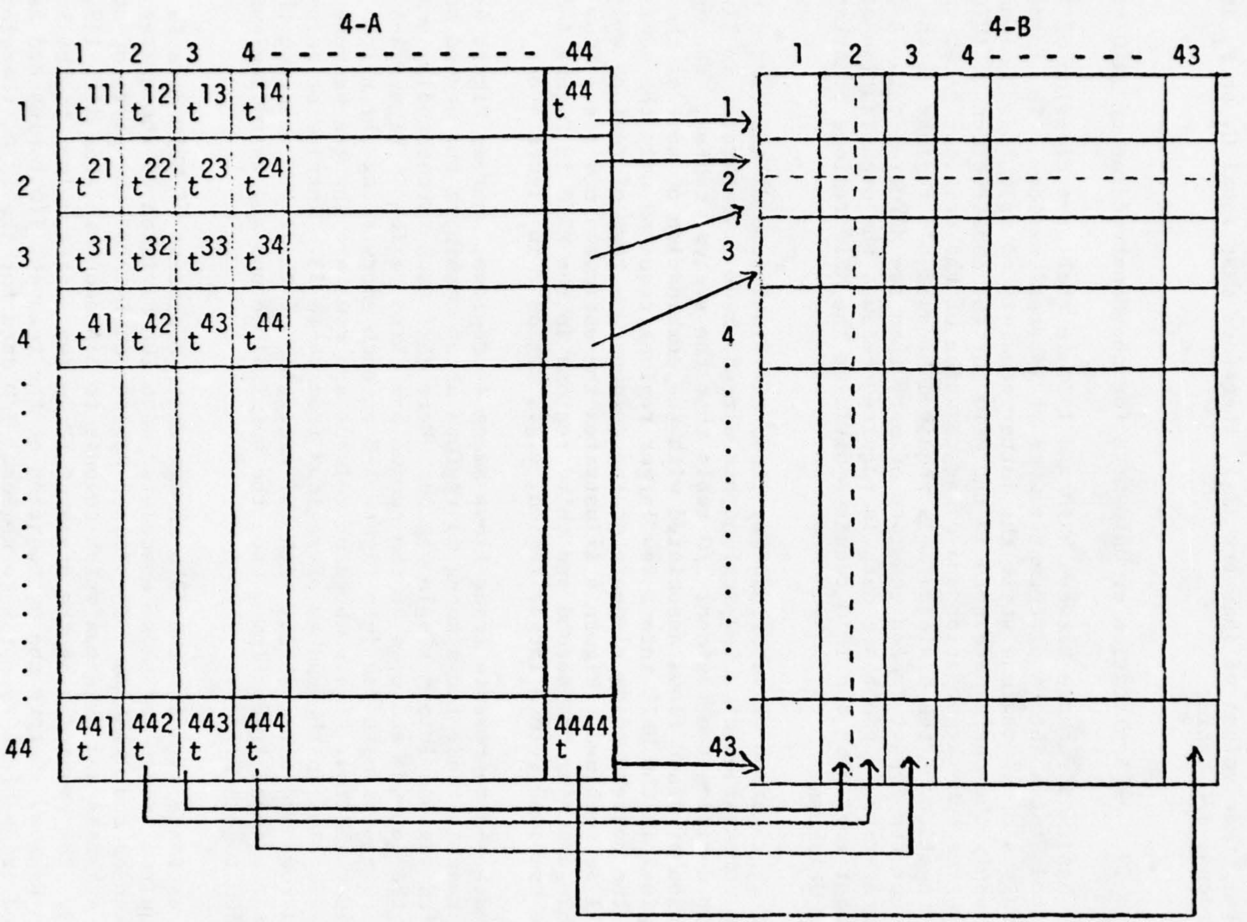
The aggregation of interindustry flows and final demands associated with the combination of a few regions has already been demonstrated in Figure 1 in deriving the regional I/O table from the states' tables. The aggregation of trade flows associated with the combination of some of the regions in the MRIO into a few larger regions requires only the addition of the corresponding elements of the columns and rows of regions which will be combined. Figure 4 illustrates the estimated new trade flow table assuming the second and third regions in the MRIO in Figure 4-A are combined into a larger region, e.g., Region 2 in Figure 4-B.

Figure 4-A represents trade flows among 44 regions, whereas Figure 4-B represents trade flows among 43 regions after combining the second and third regions into a single region. Note that each corresponding entry of the columns and rows of the second and third region in Figure 4-A are added and transferred into Figure 4-B as each entry along the third column and row. The numbers of columns and rows are changed because of a reduction in the number of regions from 44 to 43. Entries of columns and rows are not changed, with the exception of those representing the interregional trade flows, when the original second and third regions are added together.

To estimate data for the IRIO an aggregation process of MRIO data is required except for those associated with the division of the states of Arkansas and Oklahoma. The Impact Region consists of the parts of states of Arkansas and Oklahoma which belongs to BEA economic area 117, 118, and 119. The remainder of the areas of these two states belong to the Southern Region. Before the aggregation of the relevant I/O tables and associated trade flows to estimate Regional I/O data for the IRIO, therefore, the estimation of I/O tables and associated trade flows for the divided

Figure 4

Estimate of New Trade Flow Resulting From an Aggregation of Internal Regions



areas (substate) of states of Arkansas and Oklahoma within and outside of the Impact Region is necessary. Fortunately both Arkansas and Oklahoma are independent regions in the MRIO, and there exists estimated I/O tables and associated trade flows for these states. Therefore, if the data for each pair of substates of the above two states is estimated, the estimation of regional I/O tables and interregional trade flows for the IRIO requires only the aggregation of those data sets in the MRIO and for the substates of Arkansas and Oklahoma. Let us identify each state in and outside of the impact region by adding A and B, respectively, to the regional number given to the state in the MRIO: e.g., 28A and 28B for the substates of Arkansas and 30A and 30B for those of Oklahoma.

Due to time and data limitation, the I/O tables and trade flows for the above substate's areas will be indirectly estimated by proportioning the original state's data in the MRIO.

(1) An estimate of the I/O table for the substates' areas of Arkansas and Oklahoma

The division of the above two states into two areas requires estimates of I/O tables and trade flows for four substate's areas. Unlike the aggregation of existing regions (for which the I/O tables and interregional trade flows are available), the division of a region and the indirect estimates of I/O tables and trade flows for the subregions are not simple. Dividing a regional I/O table and trade flows resulting from the division of a region, involves both conceptual and technical problems. The following section will present the basic methodologies in estimating the I/O tables of a subregion using the basic information for the original region developed in the MRIO. Since each state of Arkansas and Oklahoma is treated as an independent region, subregion here means substate. The estimate of substate I/O consists of two parts: the estimation of interindustry demand and final demands.

(A) Estimates of substates' interindustry flows.

An I/O table contains two data sets: interindustry and final demands. Interindustry flows of a region indicate the values of the flow of goods and services from various supplying industries as input to each purchasing industry in order to produce the total output by these purchasing industries. The relationship of these flows for the production of one dollar's worth of output for each purchasing industry, the input-output coefficients or technical or direct coefficients, indicate the production function of that industry in the region. To estimate interindustry flows of substates (e.g., two substates areas of Arkansas within and outside of the impact region) the production functions of the same industry within the two areas are assumed to be the same. Considering the fact that many small regional I/O tables are estimated through national technology, the application of a state's technology to its substate area is inevitable unless a survey is conducted. This means that the level of interindustry flow for each industry in the two substates areas of Arkansas may differ

due to the difference in the level of output in these areas, but the input patterns for the same industry in the two areas are the same. If one can estimate the share of the state's output for each industry within each of the substate's areas in Arkansas, the interindustry flow for each purchasing industry in each substate can be estimated by multiplying the state interindustry flows for the same industry sector by the substate's share of the state's output for that industry. Figure 5 illustrates the process of estimating interindustry flows for each of the substates of Arkansas within and outside of the impact area, given the share of state output by substate and industry.

Assuming that x_{ij} indicates cell entry of an I/O table, and that Z_{ij} is used when referring to the same entry for the interindustry flow excluding final demands. Let us also assume that substate A and B indicate state area within and outside the impact region respectively.

Z_{ij} is the value of commodity i purchased by j^{th} industry in the state of Arkansas. P_j is the value of total production of j^{th} industry in the state of Arkansas, P_j^A and P_j^B are the level of output in substates within and outside the impact region respectively, where $P_j = P_j^A + P_j^B$. α_j^A and α_j^B are the shares of state output of j^{th} industry within and outside the impact region respectively.

The i^{th} input to j^{th} industry for the substate within the project region is obtained by multiplying the value of i^{th} input to j^{th} industry of the state (Z_{ij}) by the substate's share of state output of j^{th} industry (α_j^A). The substate outside the impact region will be estimated by $Z_{ij} \cdot \alpha_j^B$. The outputs by industry in the area of Arkansas, within and outside the impact region in 1963, can be estimated from the "1963 Output Measures for Input-Output Sectors by County" developed by Jack Faucett Associates.[5] Since the impact region is so organized that counties are not divided, the output level of each industry in the substate area can be obtained by adding the same output by county included in the substate area. The values of 1963 output for the states of Arkansas and Oklahoma and their substates' areas by 79 industrial sectors, and their substates' shares (α_j^A and α_j^B) for each state, are shown in Appendix A. To distinguish each of the variables associated with different states, the number given to each state as a region may be shown as its superscript. For example, Z_{ij}^{28} indicates cell entry of interindustry flows for the state of Arkansas based on the regional number given by MRIO, and Z_{ij}^{28A} indicates that of the substate in the impact area, abbreviated region 28A. The same procedures are followed for the estimate of interindustry flow for the substates of Oklahoma.

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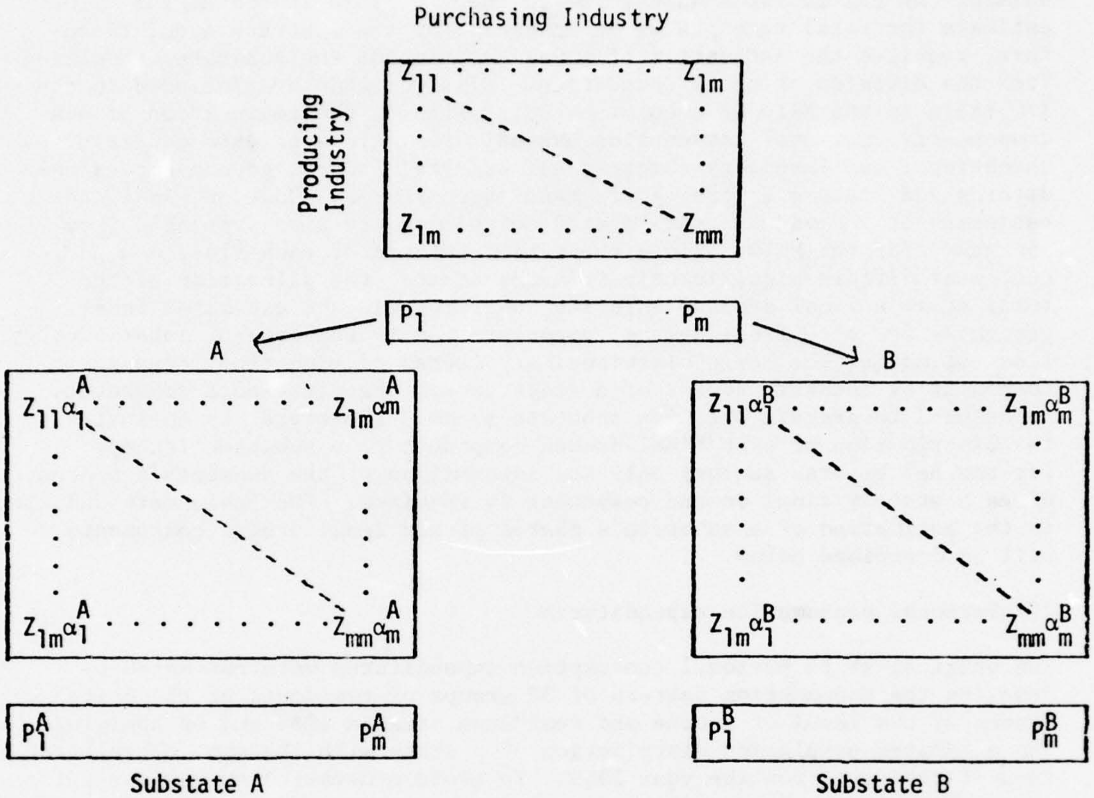
[5] (Jack) Faucett Associates, Inc., "1963 Output Measures for Input-Output Sectors by County" prepared for the Office of Civil Defense, U.S. Department of Defense, December, 1968.

Figure 5
Estimates of Substate's Interindustry Flows for the State of Arkansas



Z_{ij}'s: interindustry flows from i^{th} industry to j^{th} industry

P: column total which includes value added; superscript indicates region, subscript, industry

α_i: substate share of state output of i^{th} industry, superscript indicates substate.

(B) Estimates of final demands for a substate

Both interindustry and final demands for a commodity in a region consist of total regional consumption or receipts of the commodity. The total receipts of a commodity by a region in the MRIO model are estimated by summing the particular industry row in the I/O table of the region. To estimate the total receipts of an industry for the substate area, therefore, requires the estimation of final demands for the substates resulting from the division of state boundaries. Final demands are included in the I/O table in the MRIO as a column vector which is the aggregation of six components: personal consumption expenditures; gross private capital formations; net inventory changes; net exports; federal government expenditures and state and local government expenditures. However, independent estimates of individual final demand components are also available from the study for the MRIO. Since the demand pattern of each final demand component differs significantly from the others, the allocation of the total state's final demands into its substates will be estimated independently for each final demand component. As in the case of interindustry flow estimates, the basic distribution patterns of each final demand component by industry sector of a state except the net export component, is assumed to prevail over its substate areas. Therefore, to estimate the distribution of each final demand component to a substate (except for the net exports sector) only the information of the substate's shares of each state's final demand component is required. The basic methodologies in the estimation of a substate's shares of six final demand components will be described below.

(2) Personal consumption expenditures

The original state personal consumption expenditures were estimated by assuming the consumption pattern of 32 groups of residents of the United States by the level of income and residence area in 1960 and by applying the estimated population distribution of a state with the same classification of residents for the year 1963. To avoid a detailed survey for this study the pattern of classification of income groups and their consumption patterns for substates' areas are assumed to be equal to those of the state. The substate's share of personal consumption expenditures for a state is estimated by the substate's share of the total state's personal income. An implicit assumption is that the consumption pattern per capita income is the same throughout a state. The personal income of a substate area will be estimated by adding the estimated county personal income in 1963. County personal income data is available from the estimates of either the Bureau of Economic Analysis or a state agency. The shares of personal income (γ) in the impact region and outside the impact region in each part of the states of Arkansas and Oklahoma are given in Appendix B. The final demand vector of the personal consumption expenditures for a substate area is estimated by multiplying that of the state by the substate's share of the state's personal income.

(3) Gross private capital formation

In the MRIO study, the gross private capital formation consists of investments in equipment and plant. The investment in equipment was estimated by multiplying the capital expenditures of each industrial sector by the 1963 capital coefficient matrix.[6] The investment in equipment is estimated by summing each row of capital input to each capital purchasing industry. Investment in plant was estimated as the investment in I/O sector 11 (new construction). No information is available for the values of capital purchases breakdown by industry nor by county basis. The investment demand for each industry in a substate's area, therefore, will be estimated by prorating the substate's share of the aggregated state's output of all industries. The implicit assumption is that the distribution pattern of the capital formation in a substate's area, by industry, is the same as that of the state. The substate's shares of output of all industries (β) within and outside of the impact region in each of the states of Arkansas and Oklahoma are already shown in Appendix A. A final demand vector of the gross private capital formation for a substate will be estimated by multiplying that of the state by the substate's share of the aggregation of all industrial outputs.

(4) Net inventory changes

In the original study, net inventory changes in a state were estimated by allocating the national inventory figures in each industry sector by the state's share of output of that industry. Following the same pattern of estimation of the gross private capital formation in this study, the net inventory changes of a substate will be estimated by multiplying the state inventory changes by the substate's share of the sum of the state's output for all industries.

(5) Net exports

In the original study, net exports of a state were estimated in terms of state of exit. In this study, the net exports of a commodity based on the substate's share of the state's output of that industry. This implicitly assumes that the weighted average distance for the exports from the substates' are equal, and the proportion of domestic demand for the exported goods is proportional to the aggregated industrial output level of each substate area. Unlike other final demand components, net exports for a substate area will not be estimated by prorating the total value of net exports into a substate. Instead, net export by each industrial sector of a state will be prorated into substate's area according to the substate's share of total state's output by industry. The substates'

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[6] (Jack) Faucett Associates, Inc., "Development of Matrix of Interindustry Transaction in Capital Goods in 1963," prepared for the Bureau of Labor Statistics, U.S. Department of Labor, 1966, Appendix D.

shares of output by industries (α_i) required to divide the states of Arkansas and Oklahoma are shown in Appendix A.

(6) Federal Government expenditures

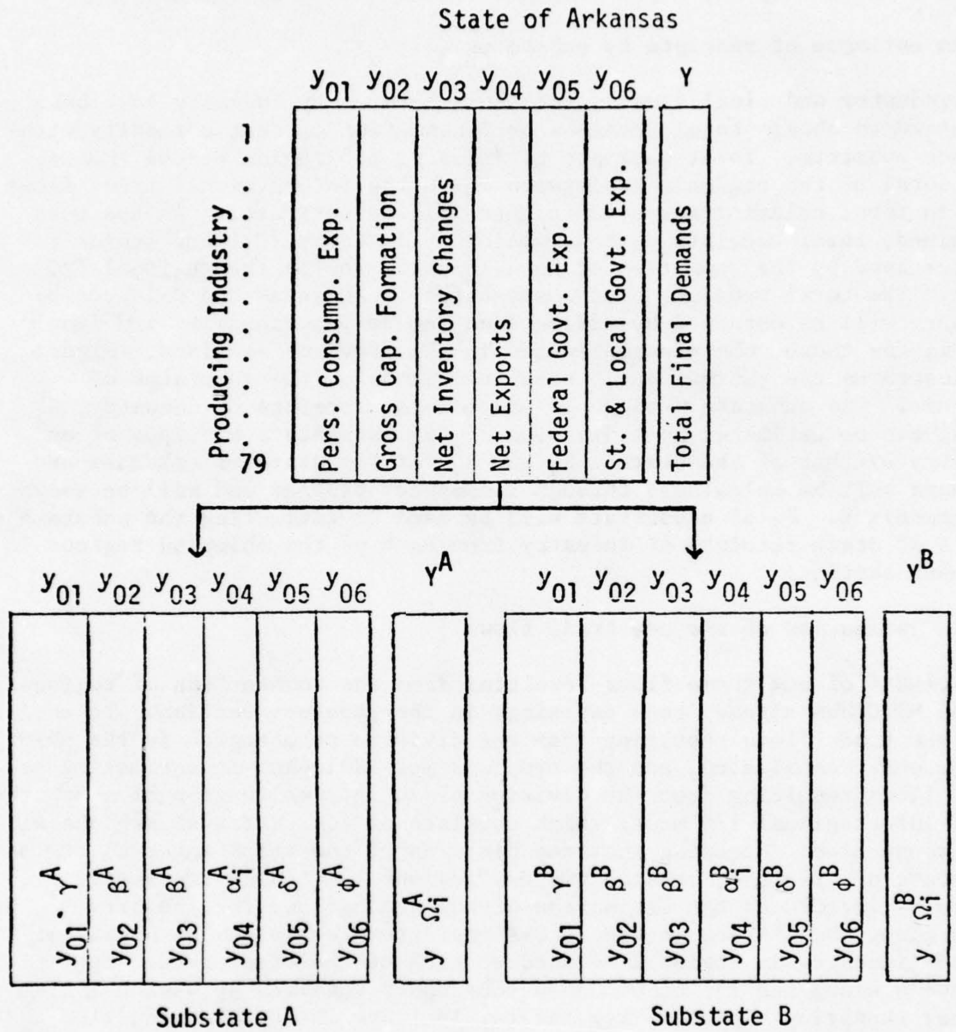
The estimate of Federal Government expenditures for a state is one of the most unsatisfactory factors of the original study. The estimated Federal Government expenditures for a state to a substate will be allocated by the ratio of wages and salaries paid out to federal employees, both for civilian and military, in the substate to those of the state. The distribution pattern of federal expenditures by industry sector in a substate is assumed to be the same as that of the state. Wages and salaries for the federal employees of each county area are available from the personal income data used in the estimation of personal income in a substate. The shares of personal income attributable to the federal employees in the substates' (δ) within and outside of the impact region in each of the states of Arkansas and Oklahoma are shown in Appendix C. Since the wages and salaries for this employment are not fixed to the total federal expenditures in the state area, a substate's share of wages and salaries for the federal employees serves only as a crude guide in estimating the total federal expenditures in the substate. The final demand vector of federal expenditures of a substate area will be estimated by multiplying that of the state by the substate's share of state personal income attributable to federal employees.

(7) State and local government expenditures

Fairly detailed information of state and local government expenditures are available from the Census of Governments. The estimated state and local government expenditures in the original study will be allocated to a substate area by the ratio of the total local government expenditures in the substate to that of the state as a whole. The implicit assumption is that the state government expenditures will be spent in the substate area according to the substate's share of the total local government expenditures in that state. The distribution pattern of local government expenditures by industry in a substate area is assumed to be the same as that of the state. To arrive at a substate's share of local government expenditures, the local government expenditures by county listed in the Census of Government, 1962 (Bureau of Census) will be used. The substates' shares of the total local government expenditures (ϕ) within and outside the impact region in each of the states of Arkansas and Oklahoma are shown in Appendix D. The final demand vector of the state and local government expenditures of a substate will be estimated by multiplying that of the state by the substate's share of total local government expenditures.

An estimate of the final demands for subregions resulting from the division of a region in the MRIO model, in this case, the division of Arkansas into substates within and outside the impact region will be illustrated in Figure 6. Y_{ij} indicates industry i which belongs to j^{th} component of final demands. γ, β, α_i, δ, and ϕ indicate that the substate's shares of personal income, aggregated output for all industries, output for industry

Figure 6
Estimates of Final Demands for Substates of Arkansas



γ, β, α_i, δ, ϕ, Ω_i indicate substates' share of state personal income; output for all industries combined; output for industry i; personal income for federal employees; local government expenditures; and the substate's share of aggregated state final demand for i^{th} industry.

i, personal income attributable to federal employees, and local government expenditures in and outside the impact region are differentiated by A and B superscript respectively. Ω_i indicates the substate's share of aggregated final demands for the state by industry and is the weighted sum for a substate's shares of each final demand component by industry. To avoid complexity the superscript to indicate Arkansas is not shown.

(C) An estimate of receipts by substates

Interindustry and final demands for the substates by industry have been estimated to obtain total receipts or consumption of that commodity within each substate. Total receipts by industry and region become the control total of the region's trade with which the interregional trade flows and, in turn, column trade coefficients will be estimated. As has been explained, total receipts or consumption by industry (C_i^r) for region r is expressed by the summation of each industry row in the regional I/O table. The total receipts of the substates in Arkansas and Oklahoma by industry will be obtained by adding each row of interindustry and final demands for those substates estimated in the previous sections. Figure 7 illustrates the estimation of total receipts for the substates of Arkansas. The substate's share of state total receipts by industry, Π_i^A or Π_i^B, can be estimated by a division of the substate's receipts of an industry by that of the state. Π_i^A and Π_i^B for the state of Arkansas and Oklahoma will be calculated through a computer program and will be shown in Appendix E. Π_i of a substate will be used in estimating the substate's shares of state receipts of industry from each of the shipping regions in the next section.

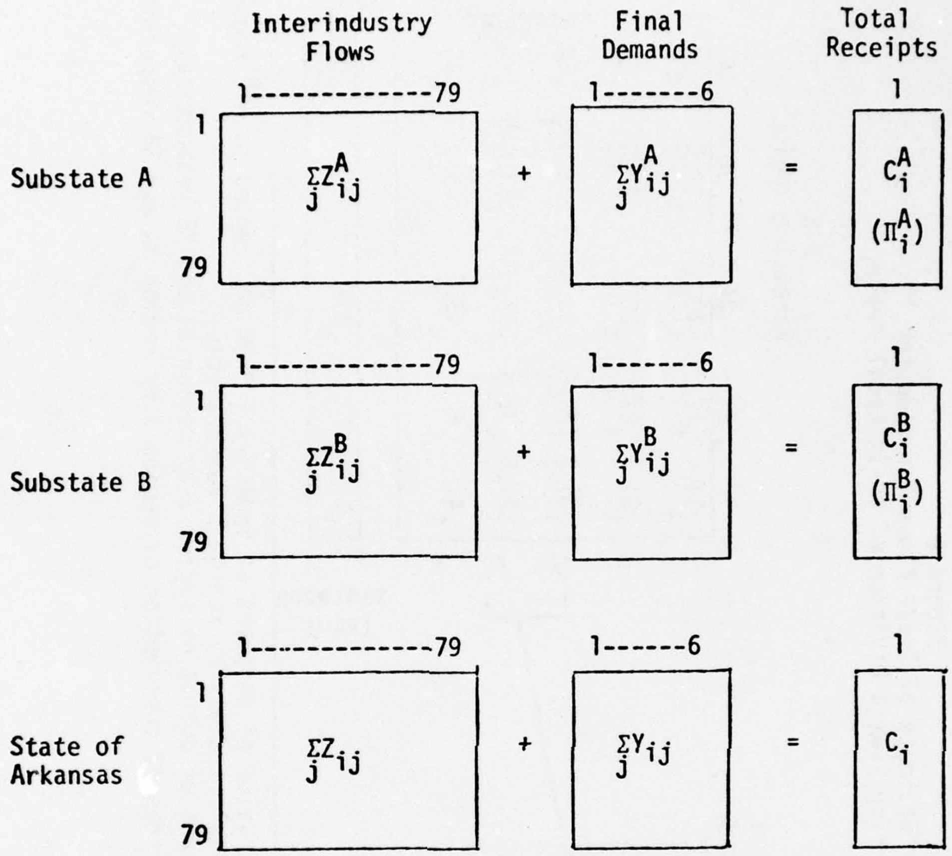
(D) An estimation of the new trade flows

An estimate of new trade flows resulting from the combination of regions in the MRIO has already been explained in the previous section. To estimate new trade flows resulting from the division of a region in the MRIO is somewhat complicated, and the proposed methodologies in estimating new trade flows resulting from the division of an internal region of a hypothetical interregional I/O model which consists of four internal regions will be demonstrated. Assuming that the division of the third internal region, the state of Arkansas, creates two new regions (3A and 3B respectively). Figure 8 illustrates the estimation of new trade flows for industry 1. t^{1h}'s along the 1st row in Figure 8-A indicates the values of output of the 1st industry in Region 1 shipped to each of the other receiving regions, and t^{g1}'s along the 1st column show the inputs received by Region 1 from various supplying regions. t_{10} and t_{01} indicate the total production and demand for industry 1 by Region 1 respectively which are not necessarily equal.

To estimate trade flows for Regions 3A and 3B with other regions, without conducting an actual survey, the following assumptions are made:

a. The value of shipment which was shipped to each purchasing region from Region 3 is originated from subregion 3A and 3B respectively and is

Figure 7
Estimates of Total Receipts by Industry and Substate of Arkansas



Z_{ij}: interindustry flow from i^{th} industry to j^{th} industry.

Y_{ij}: final demand for i^{th} industry in j^{th} component.

C_i: total receipts or consumption for i^{th} industry by the state.

π^A_i, π^B_i: indicate substates' shares of state's consumption by substate's A and B respectively, and derived by C^A_i/C_i & C^B_i/C_i respectively.

Figure 8
An Estimate of Trade Flows for Industry 1
Resulting From a Division of an Internal Region

8-A

Shiping Region	Receiving Region 1	2	3	4	Total Output
1	t^{11}	t^{12}	t^{13}	t^{14}	t^{10}
2	t^{21}	t^{22}	t^{23}	t^{24}	t^{20}
3	t^{31}	t^{32}	t^{33}	t^{34}	t^{30}
4	t^{41}	t^{42}	t^{43}	t^{44}	t^{40}
Total Receipts	t^{01}	t^{02}	t^{03}	t^{04}	

8-B

	Receiving Region 1	2	3A	3B	4	Total Output
1	t^{11}	t^{12}	$t^{13}\pi_1^A$	$t^{13}\pi_1^B$	t^{14}	t^{10}
2	t^{21}	t^{22}	$t^{23}\pi_1^A$	$t^{23}\pi_1^B$	t^{24}	t^{20}
3A	$t^{31}\alpha_1^A$	$t^{32}\alpha_1^A$	$t^{33}\alpha_1^A\pi_1^A$	$t^{33}\alpha_1^A\pi_1^B$	$t^{34}\alpha_1^A$	t^{3A0}
3B	$t^{31}\alpha_1^B$	$t^{32}\alpha_1^B$	$t^{33}\alpha_1^B\pi_1^A$	$t^{33}\alpha_1^B\pi_1^B$	$t^{34}\alpha_1^B$	t^{3B0}
4	t^{41}	t^{42}	$t^{43}\pi_1^A$	$t^{43}\pi_1^B$	t^{44}	t^{40}
Total Receipts	t^{01}	t^{02}	t^{03A}	t^{03B}	t^{04}	

1) t^{gh}, t^{go}, and t^{oh} indicate value of shipment of industry 1 from g^{th} region to h^{th} region; total output by region g; and total receipts by region h respectively.
2) α_1^A and α_1^B indicate the shares of output of region 3 by region 3A and 3B respectively.
3) π_1^A and π_1^B indicate the shares of consumption of region 3 by region 3A and 3B respectively.

proportionate with each substate's share of state's output: α_1^A and α_1^B respectively.

b. The receipts of Industry 1 by Region 3 from each of the other shipping regions were consumed by Subregions 3A and 3B proportionate to each substate's share of the state's demand for that commodity (Π_1^A and Π_1^B respectively). The row entries for Region 3A and 3B can thus be estimated by multiplying each row entry of Region 3 in Figure 8-A (t^{3g}) by α_1^A and π_1^B respectively, and the column entries for Region 3A and 3B are estimated by multiplying each column entry of Region 3 (t^{h3}) by Π_1^A and Π_1^B respectively. The new row and column entries for Regions 3A and 3B and their derivations are shown in Figure 8-B. Note that the value of shipments and receipts between the two divided subregions, including those values from their own subregions, are estimated by multiplying the value of internal shipments in Region 3 (t^{33}) by the joint product of the subregions' shares of output and demands for Industry 1 by Region 3, i.e., $t^{33}\alpha_1^A\Pi_i^A$; $t^{33}\alpha_1^A\Pi_1^B$; $t^{33}\alpha_1^B\Pi_1^A$; and $t^{33}\alpha_1^B\Pi_1^B$. $t^{33}\alpha_1^A\Pi_1^A$ and $t^{33}\alpha_1^A\Pi_1^B$ indicate the values of shipments of Industry 1 from Region 3A to 3A and 3B respectively, and $t^{33}\alpha_1^B\Pi_1^A$ and $t^{33}\alpha_1^B\Pi_1^B$ indicate those values from Region 3B and 3A and 3B respectively. α_1^A and α_1^B for the states of Arkansas and Oklahoma are shown in Appendix A and Π_1^A and Π_1^B in Appendix E.

In the original MRIO model no trade flows were assumed for service industries. This assumption was made due to the lack of data in estimating trade flows for service sectors. Since no trade means that the off diagonal of the trade flow matrix in Figure 8-A is zero, the trade flows of the service sector which were represented by $t^{3h}\alpha$ and $t^{g3}\pi_i$ are zero except $t^{33}\alpha_i\pi_i$. The same assumption is adopted in IRIO; i.e., the substates A and B of Arkansas are to be self-sufficient for service products. In order to ensure this, however, two adjustments are required associated with the model of disaggregating state trade flows for service industries. First, to ensure that the demand for service products in each substate are self-sufficient, $t^{33}\alpha_i^B\pi_i^A$ and $t^{33}\alpha_i^A\pi_i^B$ are reduced from substate B and A and added to substate A and B respectively. Second, to ensure that demand for and output of service products by each substate are balanced, the actual difference between output and demand by each substate (the residuals of the service product) are entered in the final demand matrix as a residual column; and the final demand is so adjusted that the sum of rows of the service sector equals that of the column. The service sectors which were assumed to have no trade are: I/O sectors 3, 4, 11, 12, 65, 66, 67, 68, 69, 71, 72, 75, 76, 77, 78, and 79.

V. Construction of Structural Coefficients for the IRIO

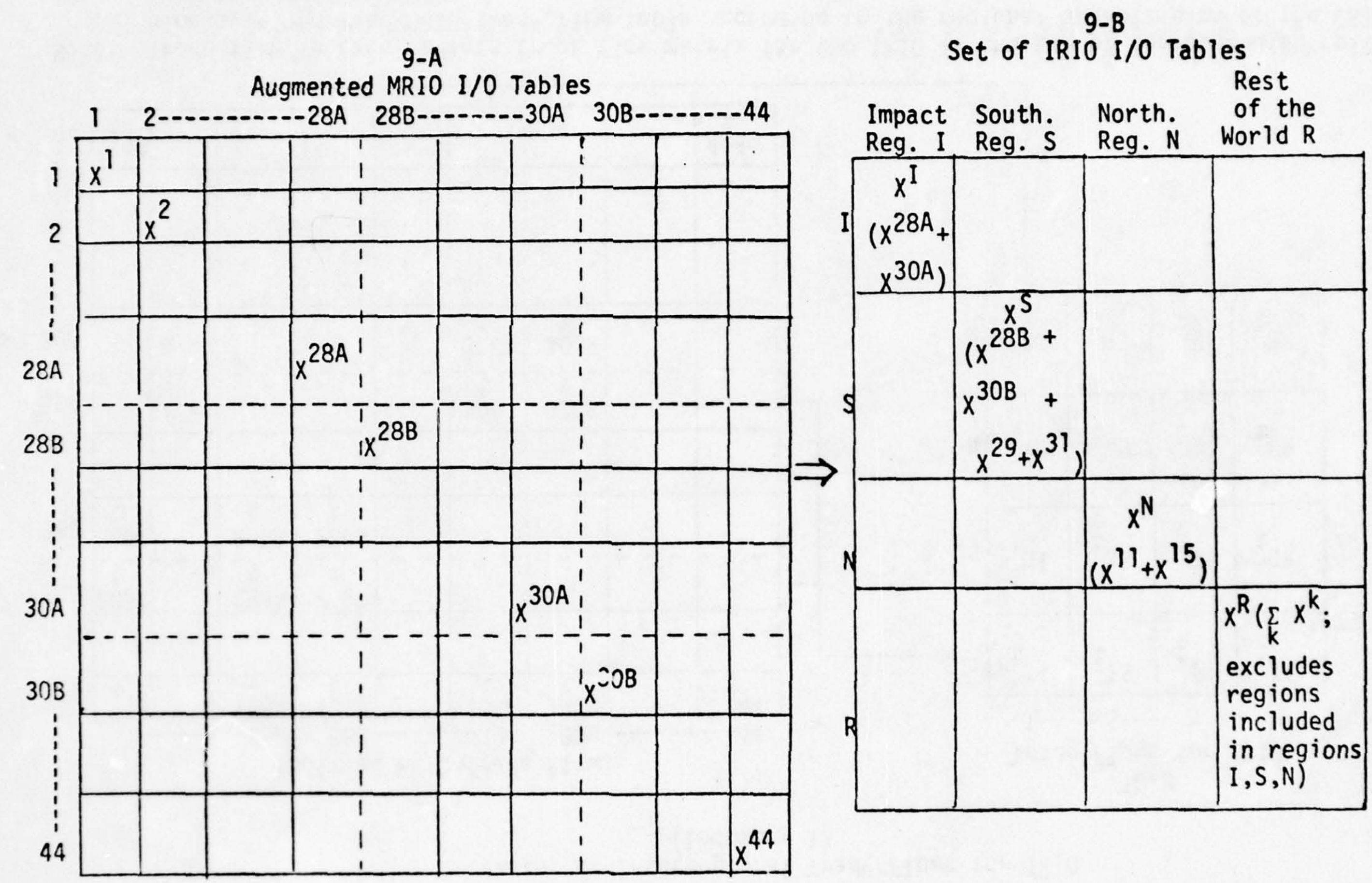
The basic methodologies which have been developed for the aggregation and disaggregation of the regional interindustry flows and final demands and interregional trade flows in the MRIO are used in the determination of structural coefficients for the IRIO (regional technical coefficients and interregional trade coefficients). The structural coefficients with the given final demand vectors, which will be developed from the project investments, are integral parts of the IRIO in the impact study. Final demand vectors for the IRIO must be developed independent of the IRIO model. to estimate structural coefficients for the IRIO the following methods will be used: (1) to estimate I/O tables and trade flows for substates in and outside the impact region in each of the states of Akransas and Oklahoma; (2) to reorganize the 44 regional I/O tables and interregional trade flows in the MRIO into 46 regional models by replacing those estimated data for each of four substates as an independent region; (3) to construct interindustry and interregional flow tables for the IRIO which consists of four internal regions; (4) to compute regional technical coefficients and interregional trade coefficients by dividing each row entry of purchasing industry and region by the corresponding column total. The estimation procedures about the interindustry and interregional trade flows associated for the division of two states into each of two substate's have been explained previously and are not repeated here.

Since the estimates of I/O table and trade flows for a substate and the modification and reorganization of data sets in the MRIO into the IRIO involves complicated procedures, it is necessary to clarify the use of the new estimates and the relationships among various data sets through a set of figures. The relationships of the number of regions between the modified MRIO and IRIO is shown in Appendix F. Figure 9 shows the relationships among the original and augumented sets of I/O tables in the MRIO and the construction of new I/O tables for the IRIO. Each regional I/O table is expressed in terms of X^k where superscript indicates the region. The original numbers for each MRIO region remain the same. However, due to the division of the states of Arkansas and Oklahoma, these two states' I/O tables were replaced by four new tables representing each substate. Each substate is assigned a new regional number. The two substates of Arkansas are labeled as 28A and 28B and the two substates of Oklahoma as 30A and 30B.

A brief methodology in estimating the I/O table for the region of 28A, part of the state of Arkansas in the impact region, is explained in the previous chapter. The same method will be used in estimating the I/O tables for any part of region in the MRIO, if the variables which are relevant to that part of region are estimated.

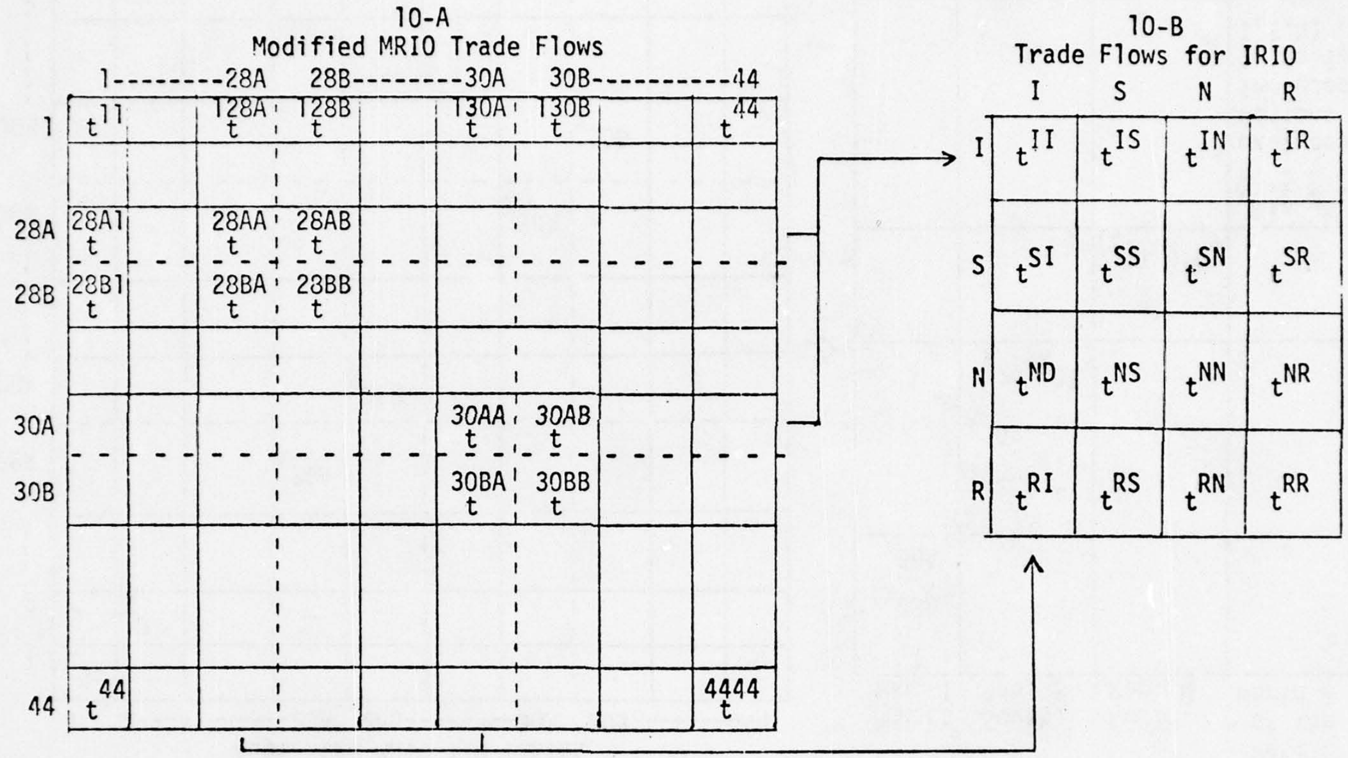
Figure 10 illustrates how the MRIO trade flow table for Industry 1 is modified from the 44 regional model to a 46 region model. As explained in the estimates of regional I/O tables, the original regional numbers

Figure 9
Estimates of I/O Tables for IRIO



Note: The I/O Table for each region consists of 83 sectors of which 79 are producing sectors

Figure 10
Estimates of Interregional Trade Flows for IRIO
(Industry 1)



Note: Trade flow in each cell in trade flow matrix for the IRIO is the sum of corresponding cell blocks in modified MRIO trade flow table according to the regional organization of the IRIO from the modified MRIO.

are kept with the exception of those for Arkansas (28) and Oklahoma (30) which were replaced by four new numbers for the substates: 28A, 28B, 30A, and 30B. Each row entry for the divided part of the region is estimated by multiplying the original cell entry, before the division of a region, by each subregion's share of regional consumption (π_i^k), and each column entry for the subregion will be estimated by multiplying a corresponding entry for the region by each subregion's share of output of Industry i in the region (α_i^k). Note, however, that trade flows between two divided subregions including intraregional flows are estimated by multiplying the original entry both by shares of substate's consumption and by the output of an industry, except service industries.

The interregional trade flow table for the IRIO can be estimated by aggregating the proper rows and columns in the modified MRIO trade flow table. The trade flows for commodity i in the IRIO, t_i^{gh}'s are obtained by summing the trade flows among regions in the modified MRIO (Figure 10) which will be accommodated in the cell block in the IRIO trade flow table according to the regional classification. Figure 10 illustrates trade flows for only one commodity. There are 79 sets of trade flows according to the industry's classification. However, with the exception of two sectors, most service industries have been so adjusted that have zero trade.

Estimates of regional I/O tables and interregional trade flows are required to estimate structural (interindustry as well as interregional) relationships for the I/O model. Figure 11 illustrates technical and trade coefficients for the IRIO. These were derived by the division of each row entry of a column of tables by the column total.[7]

Technical coefficients (A_{ij}) represents interindustry input requirements to produce one dollar's worth of output by a purchasing industry in a region. The I/O model contains four regional technical coefficients matrices. Each matrix has dimensions of 79 x 79 and is arranged into a block diagonal matrix (A) of 4 x 4 (see Figure 11). Trade coefficients (T_i^{gh}), the proportion of each commodity received by a region from various shipping regions, are also arranged into block matrices with 4 x 4 dimensions. Each block matrix is a 79 x 79 diagonal matrix and each row or column in this matrix represents one industry.

---

[7] Column total to derive technical coefficients is not the sum of 79 industry sectors, but should include value added sectors for each industry.

Figure 11
Structural Coefficients

11-A
Regional
Technical Coefficients
$A = A_{ij}$'s
$(4 \cdot 79 \times 4 \cdot 79)$

	I	S	N	R
I	A^I_{ij}	0	0	0
S	0	A^S_{ij}	0	0
N	0	0	A^N_{ij}	0
R	0	0	0	A^R_{ij}

11-B
Column
Trade Coefficients
$T = t^{gh}$'s
$(4 \cdot 79 \times 4 \cdot 79)$

	I	S	N	R
I	0 0	0 0	0 0	0 0
S	0 0	0 0	0 0	0 0
N	0 0	0 0	0 0	0 0
R	0 0	0 0	0 0	0 0

VI. Mathematical Note for the Interregional I/O Model

The theoretical model employed for the recommended I/O model is the fixed column coefficient model in which the patterns of a commodity trade from one region to other regions are expressed in terms of fixed trade coefficients (percentage shares of total receipts of the commodity by the receiving region). Thus T_i^{gh}'s are the proportion of the total consumption of commodity _i_ in region _h_ that is shipped from region _g_ to region _h_. Other structural coefficients (technical coefficients) are distinguished by region, i.e., a_{ij}^s. The following basic sets of equations specify the economic relationships between industries and regions:

1) $x_i^{og} = \sum_{j=1}^{m} a_{ij}^{g} x_j^{go} + y_i^g$

2) $x_i^{gh} = t_i^{gh} x_i^{oh}$

3) $x_i^{go} = \sum_{h=1}^{n} x_i^{gh}$

4) $x_i^{oh} = \sum_{g=1}^{n} x_i^{gh}$

where $i = 1,\ldots, m$; $g, h = 1,\ldots,n$.

x_i^{go} is the total amount of commodity _i_ produced in region _g_.

x_i^{oh} is the total amount of commodity _i_ demanded by all final and intermediate consumers in region _h_.

y_i^g is final demand for commodity i in region g.

The first equation shows that the total amount of commodity _i_ demanded by the intermediate and final users in a region must be equal to the total amount of the commodity supplied to the region. This equation is used in all multiregional input-output models. The second equation states that a commodity is shipped between regions _g_ and _h_ according to the fixed proportion of the total amount of commodity _i_ purchased by region _h_. The third and fourth equations simply define the total production in region _g_ and the total consumption in region _h_, respectively.

The multiregional I/O model can be expressed in terms of the following matrix notations:

$$\underset{(nm.nm)}{A} = \begin{bmatrix} A^1 & & & 0 \\ & A^2 & & \\ & & \ddots & \\ 0 & & & A^n \end{bmatrix} \quad \text{where} \quad \underset{(m.m)}{A^r} = \begin{bmatrix} a^r_{11} & \cdots & a^r_{1m} \\ a^r_{21} & \ddots & \vdots \\ \vdots & & \vdots \\ a^r_{m1} & \cdots & a^r_{mm} \end{bmatrix}$$

$$\underset{(nm.nm)}{T} = \begin{bmatrix} T^{11} & T^{12} & \cdots & T^{1n} \\ T^{21} & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ T^{n1} & \cdots & & T^{nn} \end{bmatrix} \quad \text{where} \quad \underset{(m.m)}{T^{gr}} = \begin{bmatrix} t^{gr}_1 & & & 0 \\ & t^{gr}_2 & & \\ & & \ddots & \\ 0 & & & t^{gr}_m \end{bmatrix}$$

$$\underset{(nm.1)}{X} = \begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^n \end{bmatrix} \quad \text{where} \quad \underset{(m.1)}{X^r} = \begin{bmatrix} x^r_1 \\ x^r_2 \\ \vdots \\ x^r_m \end{bmatrix} \qquad \underset{(nm.1)}{Y} = \begin{bmatrix} Y^1 \\ Y^2 \\ \vdots \\ Y^n \end{bmatrix} \quad \text{where} \quad \underset{(m.1)}{Y^r} = \begin{bmatrix} y^r_1 \\ y^r_2 \\ \vdots \\ y^r_m \end{bmatrix}$$

n; region, 1,-----4, m; industry, 1,.....79

A, T, X, Y are matrices for technical coefficients, trade coefficients, gross output and final demands respectively.

The column coefficient model in the matrix equation is written as follows:

(5) $X^{or} = A^r X^{ro} + Y^r$

(6) $\sum_{r=1}^{n} X^{ro} = \sum_{r=1}^{n} T^{gr} X^{or}$

(7) $\sum_{r=1}^{n} X^{or} = \sum_{r=1}^{n} X^{ro}$

where r = 1,----,n; g = 1,----,n-1

Equations (5) and (6) can be combined to obtain:

(8) $\sum_{r=1}^{n} X^{ro} = \sum_{r=1}^{n} T^{gr} A^r X^{ro} + \sum_{r=1}^{n} T^{gr} Y^r$

Where g = 1,----,n-1. Equation (8) can be written as:

(9) $\sum_{r=1}^{n} (I - T^{gr} A^r) X^{ro} = \sum_{r=1}^{n} T^{gr} Y^r$

Where g = 1,----, n-1.

The complete set of 2mn equations in 2mn unknowns is written as:

(10) $(I - T A) X = T Y$

and when solved for X as:

(11) $X = (I - T A)^{-1} T Y$ or $X = (T^{-1} - A)^{-1} Y$

VII. APPENDICES

APPENDIX A

Estimates of Outputs in Arkansas and Oklahoma and their Sub-States' and Sub-States' Shares of Output by Industry

APPENDIX A-1

Estimates of Outputs in Arkansas and its Sub-States' and Sub-States' Shares of Output by Industry

UNIT: $1,000 (1963)

α_i^{28A}, β^{28A}: Share of Sub-State's A

α_i^{28B}, β^{28B}: Share of Sub-State's B

$i = 1.......79$

APPENDIX A-1

Outputs in Arkansas and its Sub-States' and Sub-States' Shares of Output by Industry

ARKANSAS

	Industry	State Output	Impact Region Output	Impact Region (%) Share (α_i^{28A})	Share (%) of Rest of State (α_i^{28B})
1.	Livstk & Livstk Prod	399,095	294,281	74	26
2.	Other Agr Prod	661,249	228,565	35	65
3.	Forsty & Fish Prod	14,932	6,396	43	57
4.	Agr, Forsty & Fish Svcs	65,454	22,425	34	66
5.	Iron & Fer Ores Min	1,419	879	62	38
6.	Non-Ferr Metl Ores Min	18,765	18,688	100	00
7.	Coal Mining	1,558	1,558	100	00
8.	Crude Pet & Nat'l Gas	72,526	10,163	14	86
9.	Stone & Clay Min & Quarry	26,942	20,950	78	22
10.	Chem & Fert Min Ming	10,817	9,329	86	14
11.	New Construction	445,602	347,159	78	22
12.	Main & Repr Construct	189,548	128,987	53	47
13.	Ordnance & Acces	64	00	00	00
14.	Food & Kindred Prod	745,953	584,326	78	52
15.	Tobacco Manufact	00	00	00	00
16.	Brd & Narw, Yarn & Thrd Mills	16,659	9,545	57	43
17.	Misc Textl Gods & Flr Covr	22,250	4,185	19	81
18.	Apparel	77,543	44,898	58	42

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APPENDIX A-1 Continued

ARKANSAS

	Industry	State Output	Impact Region Output	Impact Region (%) Share (α_i^{28A})	Share (%) of Rest of State (α_i^{28B})
19.	Misc Fabricat Text Prod	586	332	57	43
20.	Lumber & Wd Prod	271,026	123,396	46	54
21.	Wood Containters	13,366	5,007	37	63
22.	Househld Furn	90,457	67,332	74	26
23.	Oth Furn & Fixt	17,670	10,876	62	.38
24.	Papr & Alld Prod	190,778	79,007	41	59
25.	Paprbd Cont & Bxs	41,624	40,453	97	03
26.	Print & Pub	47,539	36,932	78	22
27.	Chem & Prod	135,655	82,564	61	39
28.	Plast & Syn Matls	926	462	50	50
29.	Drgs, Clean & Toilt Prep	365	212	58	42
30.	Paints & Alld Prod	3,168	3,166	100	00
31.	Pet Indust	139,825	4,033	3	97
32.	Rubber & Plast Prod	41,374	13,879	34	66
33.	Leathr Prod	00	00	00	00
34.	Footwr & Othr Leathr Prod	72,564	32,271	44	56
35.	Glass & Glass Prod	14,569	10,866	75	25
36.	Stone & Clay Prod	50,024	25,336	51	49
37.	Prim Iron & Steel Mfg.	2,860	2,235	78	22
38.	Prim Non-Ferr Metl Mfg	122,112	100,815	83	17
39.	Metal Container	12,122	9,095	75	25

APPENDIX A-1 Continued

ARKANSAS

	Industry	State Output	Impact Region Output	Impact Region (%) Share (α_i^{28A})	Share (%) of Rest of State (α_i^{28B})
40.	Heat, Plumb & Fabricated Metl Prod	37,870	28,872	76	24
41.	Screw Mach Prod, bolt, nuts, etc.	8,753	1,389	16	84
42.	Other Fab Metl Prod	30,810	13,994	45	55
43.	Eng & Turb	00	00	00	00
44.	Farm Mach & Equip	5,068	2,006	40	60
45.	Constr, Ming, Oil Field Mach & Equip	486	365	75	25
46.	Mat Hand Mach & Equip	8,261	336	4	96
47.	Metl Work Mach & Equip	5,405	4,165	77	23
48.	Spec Indust Mach & Equip	2,577	919	36	64
49.	Gen Indust Mach & Equip	9,587	7,249	75	25
50.	Mach Shop Prod	4,604	3,578	78	22
51.	Ofc, Comput & Account	8,351	8,351	100	00
52.	Serv Indust Mach	15,999	15,801	99	1
53.	Elect Trans & Distr Equip & Elect Indust Apparatus	49,334	27,272	55	45
54.	Hshld Appliances	133,617	133,522	100	00
55.	Elec Light & Wiring	22,728	19,177	84	16
56.	Radio, TV & Comm Equip	64,472	64,147	99	1
57.	Electr Comp & Acces	206	206	100	00

ARKANSAS

	Industry	State Output	Impact Region Output	Impact Region (%) Share (α_i^{28A})	Share (%) of Rest of State (α_i^{28B})
58.	Misc Elect Mach Equip & Supp	218	131	60	40
59.	Motr Veh & Equip	13,475	10,124	75	25
60.	Aircraft & Parts	1,075	00	00	100
61.	Other Transp Equip	29,472	27,259	92	8
62.	Prof, Scientfc & Control Instru & Supp	39,180	39,076	100	00
63.	Opt, Ophthal & Photo Equip & Supp	13,109	10,109	100	00
64.	Misc Manuf	37,538	30,614	82	18
65.	Transport & Wrhsg	259,677	201,621	77	23
66.	Comm Excpt Radio & TV Broadcasting	78,703	54,405	69	31
67.	Radio & TV Brdcstng	8,709	6,453	74	26
68.	Elect, Gas, Water & Senitary Svcs	196,112	112,732	57	43
69.	Whlsle & Ret Trade	785,406	516,256	66	34
70.	Financ & Insur	187,961	139,576	74	26
71.	Real Estate & Rental	603,731	373,747	62	38
72.	Hotls & Lodg Places; pers & Repr Svcs, excpt auto repair	97,177	69,455	71	29
73.	Business Serv	64,204	52,405	82	18

ARKANSAS

	Industry	State Output	Impact Region Output	Impact Region (%) Share (α_i^{28A})	Share (%) of Rest of State (α_i^{28B})
74.	Research & Develop	235	195	83	17
75.	Auto Repr & Svcs	82,187	59,635	73	27
76.	Amusements	28,360	26,329	93	07
77.	Med, educ Svcs & Non-profit Organ	140,268	106,449	76	24
78.	Fed Govt Enterprs	51,566	29,397	57	43
79.	State & Loc Govt Enterprse	31,269	20,456	65	35
TOTAL SUM OF ALL INDUSTRIES:		7,183,728	4,588,476	64%(β^{28A})	36%(β^{28B})

Source: (Jack) Fawcett Associates, Inc. "1963 Output Measures for Input-Output Sectors by County" Prepared for Office of Civil Defense, United States Department of Defense, December 1968.

APPENDIX A-2

Estimates of Outputs in Oklahoma
and its Sub-States' and Sub-States'
Shares of Output by Industry

UNIT: $1,000 (1963)

α_i^{30A}, β^{30A}: Share of Sub State A

α_i^{30B}, β^{30B}: Share of Sub State B

i = 1........79

APPENDIX A-2

Outputs in Oklahoma and its Sub-States'
and Sub-States' Shares of Output by Industry

OKLAHOMA

	Industry	State Output	Impact Region Output	Impact Region Share (%) (α_i^{30A})	Share (%) of Rest of State (α_i^{30B})
1.	Livstk & Livstk Prod	535,823	428,152	80	20
2.	Other Agr Prod	420,942	61,751	15	85
3.	Frstry & Fish Prod	1,236	245	20	80
4.	Agr, Frstry & Fish Svcs	20,567	5,575	27	73
5.	Iron & Feraly Ores Min	00	00	00	00
6.	Non-Fer Metl Ores Ming	4,694	54	1	99
7.	Coal Mining	5,955	4,503	77	23
8.	Crude Pet & Nat'l Gas	846,052	192,309	23	77
9.	Stone & Clay Min & Quarrying	18,870	6,984	37	63
10.	Chem & Fert Minrl Ming	00	00	00	00
11.	New Construction	953,979	314,180	33	67
12.	Main & Rep Construct	268,192	115,204	43	57
13.	Ordnance & Accessories	192	128	67	33
14.	Food & Kindred Prod	527,264	153,695	29	71
15.	Tobacco Manufactures	00	00	00	00
16.	Brd & Nrw, Yarn & Thrd Mills	1,202	1,022	85	15
17.	Misc Txtl Gds & Flr Cover	192	00	00	100

OKLAHOMA

	Industry	State Output	Impact Region Output	Impact Region Share (%) (α_i^{30A})	Share (%) of Rest of State (α_i^{30B})
18.	Apparel	43,944	10,607	24	76
19.	Misc Fab Text Prod	3,957	1,143	29	71
20.	Lumber & Wd Prod	28,776	6,964	24	76
21.	Wdn Containers	00	00	00	.00
22.	Househld Furn	11,574	1,491	13	87
23.	Oth Furn & Fixt	4,865	2,069	43	57
24.	Papr & Alld Prod	12,415	6,844	55	45
25.	Paprbd Cont & Bxs	16,068	11,490	72	28
26.	Print & Pub	81,135	32,147	40	60
27.	Chem & Prod	36,205	17,414	48	52
28.	Plast & Syn Matls	926	00	00	100
29.	Drgs, Clean & Tlt Prep	4,052	1,389	34	66
30.	Paints & Alld Prod	5,994	4,490	75	25
31.	Petrol Indust	733,760	565,159	77	23
32.	Rubber & Plast Prod	91,823	11,881	13	87
33.	Leather Products	00	00	00	00
34.	Ftwr & Oth Leath Prod	4,230	1,683	40	60
35.	Glass & Glass Prod	65,198	62,105	92	8
36.	Stone & Clay Prod	82,107	35,745	44	56
37.	Prim Iron & Steel Mfg	26,995	23,695	88	12

APPENDIX A-2

OKLAHOMA

	Industry	State Output	Impact Region Output	Impact Region Share (%) (α_i^{30A})	Share (%) of Rest of State (α_i^{30B})
38.	Primary Non-Ferrous Metl Mfg.	76,057	67,118	88	12
39.	Metal Container	2,944	423	14	86
40.	Heat, Plumb & Febricated Metal Products	146,163	99,055	68	32
41.	Screw Mach Prod, bolt, nuts, etc.	5,804	3,908	67	33
42.	Oth Fab Metl Prod	37,109	21,410	58	42
43.	Engines & Turbines	104	104	100	00
44.	Farm Mach & Equip	6,911	3,618	52	48
45.	Constr, Mining, Oil Field Mach & Equip	124,281	65,357	53	47
46.	Mat Hand Mach & Equip	2,215	228	11	89
47.	Metl Work Mach & Equip	2,118	1,776	84	16
48.	Spec Indust Mach & Equipment	8,349	1,945	23	77
49.	Gen Indust Mach & Equip	48,259	39,133	81	19
50.	Mach Shop Prod	13,438	6,624	49	51
51.	Ofc, Comput & Acctg	1,585	729	46	54
52.	Svc Indust Mach	17,204	3,159	18	82
53.	Elect Trans & Distr Equip & Elect Indust Apparatus	19,778	18,144	92	8
54.	Household Appliances	2,262	837	37	63
55.	Elec Light & Wiring	455	100	22	78

APPENDIX A-2

OKLAHOMA

	Industry	State Output	Impact Region Output	Impact Region Share (%) (α_i^{30A})	Share (%) of Rest of State (α_i^{30B})
56.	Radio, TV & Comm Equip	175,340	6,402	4	96
57.	Electr Comp & Acces	7,136	801	12	88
58.	Misc Elect Mach Equip & Supp	6,567	304	5	95
59.	Motr Veh & Equip	77,545	5,010	6	94
60.	Aircraft & Parts	458,202	257,539	56	44
61.	Oth Trans Equip	16,100	5,518	34	66
62.	Prof, Scientifc & Control Instr & Supp	9,784	8,276	85	15
63.	Opt, Ophthal & Photo Equip & Supp	184	184	100	00
64.	Misc Manufacturing	16,691	10,350	62	38
65.	Transp & Warehousing	491,224	199,576	41	59
66.	Comm Excpt Radio & TV Broadcasting	165,582	70,974	43	57
67.	Radio & TV Brdcsting	18,577	7,946	43	57
68.	Elect, Gas, Water & Sanitary Svcs	307,573	129,207	42	58
69.	Whlsle & Ret Trade	1,279,977	479,336	37	63
70.	Finance & Insur	353,314	142,422	40	60
71.	Real Estate & Rental	1,111,255	440,345	40	60
72.	Hotls & Lodg Places; pers & repr svcs, excpt auto repair	146,017	56,678	39	61

OKLAHOMA

	Industry	State Output	Impact Region Output	Impact Region Share (%) (α_i^{30A})	Share (%) of Rest of State (α_i^{30B})
73.	Business Services	200,608	68,016	34	66
74.	Research & Development	2,218	721	33	67
75.	Auto Repr & Services	135,488	59,426	44	56
76.	Amusements	43,872	19,405	44	56
77.	Med, Educ Svcs & Non-Profit Organ	285,933	119,041	42	58
78.	Fed Govt Enterprises	73,117	19,957	27	73
79.	State & Loc Govt Entrprse	68,145	2,722	40	60
	TOTAL SUM OF ALL INDUSTRIES:	10,824,669	4,523,942	42% (β^{30A})	58% (β^{30B})

Source: (Jack) Fawcett Associates, Inc. "1963 Output Measures for Input-Output Sectors by County" Prepared for the Office of Civil Defense, United States Department of Defense, December 1968.

APPENDIX B

Estimates of Share of Sub-States' Personal Income
Within and Outside of the Impact Area
in the States of Arkansas and Oklahoma Respectively

γ^{28A}, γ^{28B}: Share of Substate's A&B, Arkansas

γ^{30A} γ^{30B}: Share of Substate's A&B, Oklahoma

APPENDIX B-1
State of Arkansas
(Unit: $1,000)(1965)

OBE	County		OBE	County	
117	Arkansas	55,134	117	Pike	13,867
117	Clark	37,924	117	Pope	41,515
117	Cleburne	13,844	117	Prairie	19,007
117	Cleveland	8,679	117	Pulaski	718,794
117	Conway	27,078	117	Saline	69,479
117	Faulkner	49,156	117	Sharp	10,515
117	Fulton	8,045	117	Stone	7,114
117	Garland	107,473	117	Van Buren	9,567
117	Grant	14,652	117	White	58,335
117	Hot Spring	43,245	117	Woodruff	20,605
117	Independence	35,269	118	Crawford	37,869
117	Izard	8,934	118	Franklin	16,786
117	Jackson	39,407	118	Logan.	26,429
117	Jefferson	172,298	118	Polk	17,975
117	Johnson	19,792	118	Scott	11,619
117	Lincoln	19,541	118	Sebastian	187,408
117	Lonoke	42,526	118	Yell	26,438
117	Monroe	25,349	119	Benton	83,600
117	Montgomery	8,045	119	Madison	18,108
117	Perry	6,660	119	Washington	149,157

SUM OF THE IMPACT AREA: 2,287,238

STATE TOTAL: 3,576,700

SHARE OF THE IMPACT AREA: 64%(γ^{28A})

SHARE OF THE REST OF AREA: 36%(γ^{28B})

SOURCE: College of Business Administration, University of Arkansas, Arkansas Personal Income Handbook 1973.

APPENDIX B-2
State of Oklahoma
(Unit: $1,000)(1962)

OBE	County	
118	Haskell	7,824
118	Latimer	6,350
118	Le Flore	28,265
118	Pittsburg	54,292
118	Pushmataha	7,384
118	Sequoyah	13,807
119	Adair	10,033
119	Cherokee	17,861
119	Creek	51,474
119	Delaware	11,348
119	Kay	111,110
119	McIntosh	15,955
119	Mayes	28,418
119	Muskogee	103,639
119	Nowata	15,183
119	Okmulgee	57,498
117	Osage	37,084
119	Pawnee	11,598
119	Payne	71,549
119	Rogers	24,750
119	Tulsa	954,958
119	Wagoner	14,043
119	Washington	140,456

SUM OF THE IMPACT AREA: 1,794,879

STATE TOTAL: 4,676,603

SHARE OF THE IMPACT AREA: 38%(γ^{30A})

SHARE OF THE REST OF AREA: 62%(γ^{30B})

SOURCE: Bureau for Economic Research, University of Oklahoma, County Personal Income in Oklahoma, 1960-1970 Table B-1, 1973.

APPENDIX C

Estimates of Share of Substates' Personal Income Attributable to Federal Employees (Civilian & Military) Within and Outside of the Impact Area in the States of Arkansas and Oklahoma Respectively

UNIT: $1 Million (1962)

δ^{28A} δ^{28B}: Share of Substate's A&B, Arkansas

δ^{30A} δ^{30B}: Share of Substate's A&B, Oklahoma

APPENDIX C-1
State of Arkansas

OBE	County		OBE	County	
117	Arkansas	88.1	117	Pike	68.8
117	Clark	92.0	117	Pope	173.7
117	Cleburne	71.1	117	Prairie	41.6
117	Cleveland	24.2	117	Pulaski	5111.6
117	Conway	72.9	117	Saline	89.3
117	Faulkner	103.2	117	Sharp	32.0
117	Fulton	47.3	117	Stone	62.4
117	Garland	219.1	117	Van Buren	45.8
117	Grant	36.3	117	White	125.1
117	Hot Spring	62.2	117	Woodruff	49.4
117	Independence	101.7	118	Crawford	79.7
117	Izard	36.7	118	Franklin	52.7
117	Jackson	63.0	118	Logan	111.7
117	Jefferson	894.8	118	Polk	64.8
117	Johnson	70.3	118	Scott	52.8
117	Lincoln	31.4	118	Sebastian	4475.0
117	Lonoke	143.7	118	Yell	120.8
117	Monroe	49.9	119	Benton	168.6
117	Montgomery	63.7	119	Madison	53.3
117	Perry	50.4	119	Washington	475.2

SUM OF THE IMPACT AREA: 13,776.3

STATE TOTAL: 18,059.6

SHARE OF IMPACT AREA: (δ^{28A})76%

SHARE OF THE REST OF AREA (δ^{28B})24%

SOURCE: Printout from the Bureau of Economic Analysis, United States Department of Commerce

APPENDIX C-2
State of Oklahoma

OBE	County	
118	Haskell	92.7
118	Latimer	42.2
118	Le Flore	267.2
118	Pittsburg	674.9
118	Pushmataha	49.6
118	Sequoyah	55.1
119	Adair	47.1
119	Cherokee	145.5
119	Creek	113.3
119	Delaware	284.6
119	Kay	259.7
119	McIntosh	109.0
119	Mayes	88.1
119	Muskogee	903.1
119	Nowata	48.0
119	Okmulgee	172.4
119	Osage	146.5
119	Pawnee	87.1
119	Payne	420.5
119	Rogers	132.5
119	Tulsa	2,704.8
119	Wagoner	53.2
119	Washington	260.7

SUM OF IMPACT AREA: 7,157.8

STATE TOTAL: 44,127.2

SHARE OF IMPACT AREA: 16%(δ^{30A})

SHARE OF THE REST OF AREA: 84%(δ^{30B})

SOURCE: Printout from the Bureau of Economic Analysis, United States Department of Commerce.

APPENDIX D

Estimates of Share of Substates' State & Local Government Expenditures Within and Outside of the Impact Area in the States of Arkansas and Oklahoma Respectively

ϕ^{28A}, ϕ^{28B}: Share of substate's A&B, Arkansas

ϕ^{30A}, ϕ^{30B}: Share of substate's A&B, Oklahoma

APPENDIX D-1
State of Arkansas
(Unit: $1,000)(1962)

OBE	County		OBE	County	
117	Arkansas	3,538	117	Pike	786
117	Clark	2,196	117	Pope	1,756
117	Cleburne	1,078	117	Prairie	1,066
117	Cleveland	584	117	Pulaski	34,892
117	Conway	1,336	117	Saline	2,888
117	Faulkner	2,592	117	Sharp	649
117	Fulton	901	117	Stone	545
117	Garland	5,728	117	Van Buren	751
117	Grant	892	117	White	3,239
117	Hot Spring	2,594	117	Woodruff	1,528
117	Independence	1,563	118	Crawford	2,044
117	Izard	553	118	Franklin	1,037
117	Jackson	2,577	118	Logan	1,432
117	Jefferson	7,546	118	Polk	1,354
117	Johnson	989	118	Scott	893
117	Lincoln	1,065	118	Sebastian	6,977
117	Lonoke	2,196	118	Yell	1,247
117	Monroe	1,403	119	Benton	4,001
117	Montgomery	605	119	Madison	673
117	Perry	590	119	Washington	7,521

SUM OF IMPACT AREA: 115,805

STATE TOTAL: 198,693

SHARE OF IMPACT AREA: 58%(ϕ^{28A})

SHARE OF REST OF AREA: 42%(ϕ^{28B})

SOURCE: Bureau of Census, United States Department of Commerce, Census of Government 1962 Government in Arkansas, Vol. IV and VII.

APPENDIX D-2
State of Oklahoma
(Unit: $1,000)(1962)

OBE	County	
118	Haskell	1,208
118	Latimer	1,084
118	Le Flore	3,652
118	Pittsburg	4,184
118	Pushmataha	1,536
118	Sequoyah	2,422
119	Adair	1,616
119	Cherokee	2,152
119	Creek	5,296
119	Delaware	1,691
119	Kay	8,255
119	McIntosh	1,731
119	Mayes	3,029
119	Muskogee	8,442
119	Nowata	1,442
119	Okmulgee	4,797
119	Osage	4,824
119	Pawnee	1,662
119	Payne	5,013
119	Rogers	3,096
119	Tulsa	55,990
119	Wagoner	1,790
119	Washington	6,872

SUM OF IMPACT AREA: 131,784

STATE TOTAL: 353,998

SHARE OF IMPACT AREA: 37%(ϕ^{30A})

SHARE OF REST OF AREA: 63%(ϕ^{30B})

SOURCE: Bureau of Census, United States Department of Commerce, Census of Government 1962 Government in Oklahoma, Vol. IV and VII.

APPENDIX E

Shares of State Total Receipts by Industry and Substates Within and Outside of the Impact Region in the State of Arkansas and Oklahoma

π_i^{28A}, π_i^{28B}: Substate's A&B in Arkansas

π_i^{30A}, π_i^{30B}: Substate's A&B in Oklahoma

$i = 1, \ldots\ldots\ldots\ldots 79$

APPENDIX E

Shares of State's Total Receipts by Industry and Substates Within and Outside of the Impact Region in the States of Arkansas and Oklahoma*

	Industry	ARKANSAS (28) π_i^{28A**}	ARKANSAS (28) π_i^{28B}	OKLAHOMA (30) π_i^{30A}	OKLAHOMA (30) π_i^{30B}
1.	Livstk & Livstk Prod	.6832	.3168	.4652	.5348
2.	Oth Agr Prod	.6189	.3811	.5283	.4717
3.	Forsty & Fish Prod	.5024	.4976	.3959	.6041
4.	Agr Forsty & Fish Svcs	.4991	.5009	.1939	.8061
5.	Iron & Feroaly Ores Min	.7705	.2295	.8515	.1485
6.	Non-Ferr Metl Ores Min	.8655	.1345	.6111	.3889
7.	Coal Mining	.6001	.3999	.4844	.5156
8.	Crude Pet & Nat'l Gas	.1544	.8456	.6738	.3262
9.	Stone & Clay Min & Quaryng	.5692	.4308	.4205	.5795
10.	Chem & Fert Minrl Min	.6000	.4000	.4411	.5589
11.	New Construction	.6420	.3580	.3806	.6194
12.	Main & Repr Construct	.5806	.4194	.3734	.6266
13.	Ordnance & Accessories	.7453	.2547	.1888	.8112
14.	Food & Kindred Products	.6919	.3081	.3954	.6046
15.	Tobacco Manufactures	.6409	.3591	.3804	.6196
16.	Brd & Nrw, Yrn & Thrd Mills	.5382	.4618	.3076	.6924
17.	Misc Textl Gds & Flr Cov	.4942	.5058	.2716	.7284
18.	Apparel	.6316	.3684	.3696	.6304
19.	Misc Fab Text Prod	.6398	.3602	.3981	.6019
20.	Lumber & Wood Prod	.5303	.4697	.3492	.6508
21.	Wooden Containers	.5306	.4694	.4166	.5834
22.	Household Furniture	.7195	.2805	.3704	.6296
23.	Oth Furn & Fixtures	.6453	.3547	.4025	.5975
24.	Paper & Allied Prod	.6267	.3733	.4173	.5827
25.	Paperbrd Cont & Boxes	.6464	.3536	.4474	.5526
26.	Printing & Publishing	.7197	.2803	.3791	.6209
27.	Chemicals & Products	.5279	.4721	.4459	.5541
28.	Plastics & Syn Matls	.4875	.5125	.2117	.7883
29.	Drgs, Clean & Tlet Prep	.6517	.3483	.3900	.6100
30.	Paints & All Prod	.6475	.3525	.4350	.5650
31.	Petroleum Industries	.5240	.4760	.4756	.5244
32.	Rubber & Plastics Prod	.6633	.3367	.3511	.6489
33.	Leather Prod	.4533	.5467	.4401	.5599
34.	Footwr & Oth Leath Prod	.6179	.3821	.3828	.6172
35.	Glass & Glass Prod	.7512	.2488	.5206	.4794
36.	Stone & Clay Prod	.7028	.2972	.3674	.6326
37.	Prim Iron & Steel Mfg	.7268	.2732	.4920	.5080
38.	Prim Non-Fer Metl Mfg	.7973	.2027	.6286	.3714

APPENDIX E Continued

	Industry	ARKANSAS (28) 28A** π_i	28B π_i	OKLAHOMA (30) 30A π_i	30B π_i
39.	Metal Container	.7241	.2759	.4537	.5463
40.	Heat, Plumb & Fabricat Metal Prod	.7391	.2609	.3931	.6069
41.	Screw Mach Prod, bolt, nuts, etc.	.7801	.2199	.4104	.5896
42.	Oth Fabric Metl Prod	.6580	.3420	.4271	.5729
43.	Eng & Turb	.6870	.3130	.4056	.5944
44.	Farm Mach & Equip	.6053	.3947	.3744	.6256
45.	Constr, Min, Oil Field Mach & Equip	.6732	.3268	.4341	.5659
46.	Mat Hand Mach & Equip	.5668	.4332	.3991	.6009
47.	Metl Work Mach & Equip	.6837	.3163	.4673	.5327
48.	Spec Indust Mach & Equip	.6231	.3769	.3965	.6035
49.	Gen Indust Mach & Equip	.6787	.3213	.5149	.4851
50.	Mach Shop Prod	.7823	.2177	.5155	.4845
51.	Ofc Comput & Acctg	.7149	.2851	.3798	.6202
52.	Svc Indust Mach	.7510	.2490	.3616	.6384
53.	Elect Transmis & Distr Equip & Elect Indust Apparatus	.6864	.3136	.4136	.5864
54.	Household Appliances	.7996	.2004	.3796	.6204
55.	Elect Light & Wir	.7444	.2556	.3435	.6565
56.	Radio, TV & Comm Equip	.7461	.2539	.2597	.7403
57.	Elec Compon & Access	.9265	.0735	.1895	.8105
58.	Misc Elect Mach Equip & Supp	.6916	.3184	.3563	.6437
59.	Motr Veh & Equip	.6471	.3529	.3640	.6360
60.	Aircraft & Parts	.6623	.3377	.4010	.5990
61.	Oth Transp Equip	.6887	.3113	.3883	.6117
62.	Prof, Scientif & Control Instru & Supp	.8531	.1469	.4525	.5475
63.	Opt, Ophth & Photo Equip & Supp	.7044	.2956	.3951	.6049
64.	Misc Manufacturing	.6865	.3135	.3949	.6051
65.	Transport & Warehousing	.6445	.3555	.4084	.5916
66.	Comm Excpt Radio & TV Bdcsting	.6641	.3359	.3902	.6098
67.	Radio & TV Broadcasting	.7384	.2616	.4293	.5707
68.	Elect, Gas, Water & Sanit Svcs	.6219	.3781	.4103	.5897
69.	Wholesale & Ret Trade	.6476	.3524	.3860	.6140
70.	Finance & Insurance	.6517	.3483	.3926	.6074
71.	Real Estate & Rental	.6304	.3696	.3552	.6448

APPENDIX E Continued

Industry	ARKANSAS (28) π_i^{28A**}	π_i^{28B}	OKLAHOMA (30) π_i^{30A}	π_i^{30B}
72. Hotls & Lodg Places; pers & repr svcs, excpt auto repr	.6458	.3542	.3713	.6287
73. Business Services	.6740	.3260	.3677	.6323
74. Research & Develop***	.5000	.5000	.5000	.5000
75. Auto Repair & Services	.6466	.3534	.3799	.6201
76. Amusements	.6658	.3342	.3705	.6295
77. Med Educ Svcs & Non-Profit Organizations	.4649	.5351	.3312	.6688
78. Fed Govt Enterprises	.6205	.3795	.3352	.6648
79. State & Loc Govt Enterprise	.6565	.3435	.3867	.6133

Footnotes:

* Substate shares of total state receipts are derived by estimating each substate share of intermediate demand and each component of final demand of that state. Substate share of intermediate demand is estimated by substate share of total state output by industry and substate share of each final demand component is derived by various census data.

** Represents substate share of demand for each industry product for that state. Superscript 28 and 30 represent the states of Arkansas and Oklahoma respectively. A and B represent substate within and outside of the impact region respectively.

*** Output of industry 74 is zero. In order to insure mathematical operation π_{74} is replaced by 0.5000 for each substate.

APPENDIX F

Classification of States
for
The MRIO and IRIO

Appendix F-1 States for the MRIO & IRIO

State No	State (Abbreviation)		MRIO Reg No	IRIO Reg No
1	Alabama	AL	26	4 (R)
2	Arizona	AR	37	4
3	Arkansas	AR	28	1&2 (I&S)
4	California	CA	42	4
5	Colorado	CO	35	4
6	Connecticut	CT	3	4
7	Delaware	DE	16	4
8	D.C.	DC	17	4
9	Florida	FL	23	4
10	Georgia	GA	22	4
11	Idaho	ID	33	4
12	Illinois	IL	7	4
13	Indiana	IN	7	4
14	Iowa	IA	10	4
15	Kansas	KS	15	3 (N)
16	Kentucky	KY	24	4
17	Louisiana	LA	29	2
18	Maine	ME	1	4
19	Maryland	MD	16	4
20	Massachusetts	MA	3	4
21	Michigan	MI	6	4
22	Minnesota	MN	9	4
23	Mississippi	MS	27	4
24	Missouri	MO	11	3 (N)
25	Montana	MT	32	4
26	Nebraska	NE	14	4
27	Nevada	NV	39	4
28	New Hampshire	NH	3	4
29	New Jersey	NJ	5	4
30	New Mexico	NM	36	4
31	New York	NY	4	4
32	North Carolina	NC	20	4
33	North Dakota	ND	12	4
34	Ohio	OH	6	4
35	Oklahoma	OK	30	1&2 (I&S)
36	Oregon	OR	41	4
37	Pennsylvania	PA	5	4
38	Phode Island	RI	3	4
39	South Carolina	SC	21	4
40	South Dakota	SD	13	4
41	Tennessee	TN	25	4
42	Texas	TX	30	2 (S)
43	Utah	UT	38	4
44	Vermont	VT	2	4
45	Virginia	VA	18	4
46	Washington	WA	40	4
47	West Virginia	WV	19	4
48	Wisconsin	WI	8	4
49	Wyoming	WY	34	4
50	Alaska	AK	43	4
51	Hawaii	HI	44	4

Appendix F-2 Modified MRIO Regions for States and IRIO Region

Modified MRIO Region No	Constituent State(s) and No.	IRIO Region No.
1	Maine(18)	4 (R)
2	Vermont(44)	"
3	Connecticut(6), Massachusetts(20)	"
	New Hampshire(28), Rhode Island(38)	"
4	New York(31)	"
5	New Jersey(29), Pennsylvania(37)	"
6	Michigan(21), Ohio(34)	"
7	Illinois(12), Indiana(13)	"
8	Wisconsin(8)	"
9	Minesota(22)	"
10	Iowa(L4)	"
11	Missouri(24)	3 (N)
12	North Dakota(33)	4
13	South Dakota(40)	"
14	Nebraska(26)	"
15	Kansas(15)	3
16	Delaware(7), Maryland(19)	4
17	District of Columbia(8)	"
18	Virginia(45)	"
19	West Virginia(47)	"
20	North Carolina(32)	"
21	South Carolina(39)	"
22	Georgia(10)	"
23	Florida(9)	"
24	Kentucky(16)	"
25	Tennessee(41)	"
26	Alabama(1)	"
27	Mississippi(23)	"
28	Arkansas(3)	1&2
28A	Part of Arkansas(3A)	1 (I)
28B	Part of Arkansas(3B)	2 (S)
29	Louisians(17)	"
30	Oklahoma(35)	1&2
30A	Part of Oklahoma(35A)	1
30B	Part of Oklahoma(35B)	2
31	Texas(42)	"
32	Montana(25)	4
33	Idaho(11)	"
34	Wyoming(49)	"
35	Colorado(5)	"
36	New Mexico(30)	"
37	Arizona(2)	"
38	Utah(43)	"
39	Nevada(37)	"
40	Washington(46)	"
41	Oregon(36)	"
42	California(4)	"
43	Alaska(50)	"
44	Hawaii(51)	"

APPENDIX B

WATER RESOURCE PROJECTS GENERATING
BASIC COST DATA

Appendix B

WATER RESOURCE PROJECTS GENERATING BASIC COST DATA

The data analyzed in this study refer to the following twelve types of public development projects, for which the names and locations of individual projects are listed.

LARGE EARTH FILL DAMS	
Painted Rock Dam	Arizona
SMALL EARTH FILL DAMS	
Buckhorn Reservoir	Kentucky
Dillon Reservoir (clearing)	Ohio
Mansfield Reservoir	Indiana
LOCAL FLOOD PROTECTION	
Big Dalton Wash Channel	California
Cape Girardeau	Missouri
Woonsocket, Blackstone River	Rhode Island
PILE DIKES	
Ackley Bend to Leavenworth Reach, Missouri River	Kansas
Ashport-Goldust, Mississippi River	Arkansas
Miami to Glasgow Bend, Missouri River	Missouri
Near Bigelow, Arkansas River	Arkansas
Bend, Missouri River	Missouri
LEVEES	
Elk Chute Drainage District	Missouri
Lake Ponchartrain	Louisiana
Near Muscatine, Mississippi River	Iowa
Old Lake	Louisiana
Ripley, Mississippi River	Tennessee
Santa Maria Valley and Bradford Canyon	California
Yazoo River	Mississippi
REVETMENTS	
Arkansas River Revetment	Arkansas
Bank Paving, Mississippi River	Missouri, Tennessee Arkansas, Mississippi
Board Revetment, Red River	Louisiana
Cessions to Kempe Bend, Mississippi River	Mississippi, Arkansas, Louisiana
Sacramento River Bank Protection	California

Appendix B (Continued)

POWERHOUSE CONSTRUCTION	
Beaver Dam Powerhouse	Arkansas
MEDIUM CONCRETE DAMS	
Beaver Dam and Reservoir	Arkansas
LOCK AND CONCRETE DAMS	
Columbia Lock and Dam	Alabama
LARGE MULTIPLE-PURPOSE PROJECTS	
Glen Canyon Dam and Powerhouse	Arizona
DREDGING	
Anacostia River	District of Columbia
Atlantic Intra-Coastal Waterway, Port Royal Sound	South Carolina
Bronx River	New York
Brunswick Harbor	Georgia
Calumet-Sag Channel	Illinois
Columbia River between Bonneville and Vancouver	Washington, Oregon
Duxburg Harbor	Texas
Gulf Intra-coastal Waterway, Freeport	Texas
Intra-Coastal Waterway, Caloosahatchie River to Anclote River	Florida
Manteo to Oregon Inlet	North Carolina
Matagorda Channel, Point Lavaca	Texas
New York Harbor	New York
Philadelphia, Delaware River	Pennsylvania
Sabine-Neches Waterway	Texas
MISCELLANEOUS	
Bayou Macon Channel Improvement	Louisiana
Jetties, Gold Beach	Oregon
Outlet Channel, Sardis Dam	Mississippi
Sea Wall Extension, Galveston	Texas

Sources:

Robert H. Haveman and John V. Krutilla. Unemployment, Idle Capacity, and the Evaluation of Public Expenditures: National and Regional Analysis. Baltimore: The Johns Hopkins Press, 1968, Appendix 2, pp. 100-101.

APPENDIX C

COMPUTER PROGRAMS

Table of Contents

Computer Programs and Data

I. Introduction

In the course of the study of the inter-regional input-output models (80 and 10 sector models), the data sets of the MRIO model[1] were used as basic data in order to get technical coefficients and column trade coefficients. All programs were written in FORTRAN IV and three different computers were used due to the core size and convenience. Programs AHAT and GETC were introduced in the MRIO operating package and have been slightly modified here. Subroutine INVERT is also adapted from the BMD program.[2] The rest of the programs were created for the IRIO models.

In order to obtain the regional final demand sectors and regional outputs of the 80 sector model, two computers, UNIVAC 1108 and CDC 7600, were used. Technical coefficients and trade coefficients were computed by UNIVAC 1108 but the matrix inversion and output computations were carried out by CDC 7600 because CDC 7600 had a sufficiently larger core memory than the UNIVAC system and could handle the direct matrix inversion of a 320x320 matrix.

To prevent system problems in transferring data on the tape from one system to another system, technical coefficients and column trade

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[1] Albert J. Waldenhaug, Raymond C. Rodgers, and Howard L. Schreier "Implementation and Evaluation of the Multiregional Input-Output Model of the United States." U.S. Department of Commerce, Washington, D.C. August 1972.

[2] W. J. Dixon, Editor. "BMD Biomedical Computer Programs." University of California Press.

coefficients were punched on cards from the UNIVAC system and fed into the CDC system. Flow charts for the operating procedures using both systems are shown in Figures 1 and 2. Data sets on tapes and cards are tabulated on Tables I and II. Figures 3 and 4 show the flow charts for operating procedures using UNIVAC 1108 and IBM S/360. There was no particular reason for switching UNIVAC to IBM to execute the program SENFIN, except for convenience of computer use. There were two computer programmers involved in the computer programming. One of the programmers was responsible for writing the source programs and the other was responsible for the system analyzing and modification of programs whenever needed for the specific computer. It should be noticed that subroutine, NTRAN, is a subroutine in the UNIVAC system for tape handling (see Appendix A for details). This subroutine can be replaced by ordinary statements like WRITE, READ, and REWIND. In programs, requesting a large core memory in the CDC system, LARGE is used instead of the DIMENSION statement. Program, FINAL, may be modified without great difficulty to reduce the core storage requirement by partitioning the matrix. The inverse matrix is already partitioned into 4 rowsx4 columns sub-matrices as shown in Appendix B. Computer programs are arranged in order following the job steps. Subprograms for the print-out of the matrices are quite similar to each other, but are retained as are.

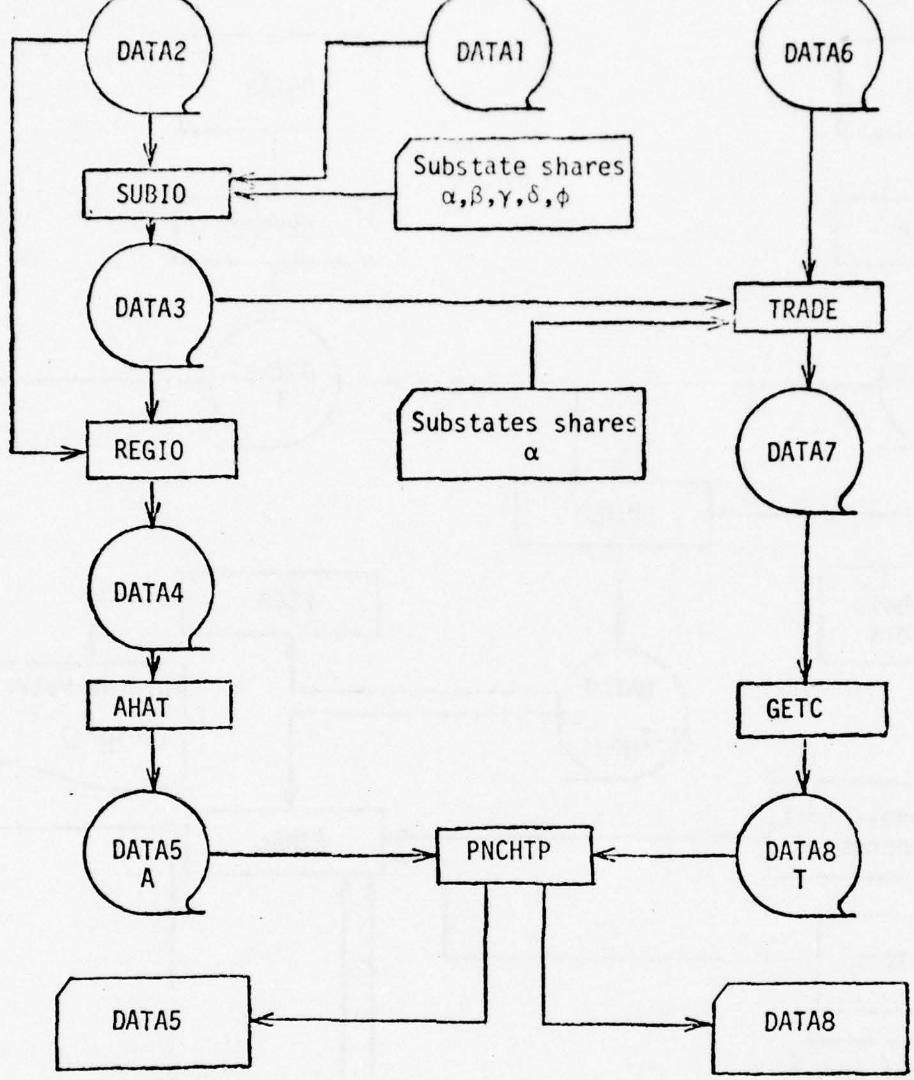

Figure 1
Flowchart for Operating Procedures
Using UNIVAC 1108 Computer for 80 Sector Model

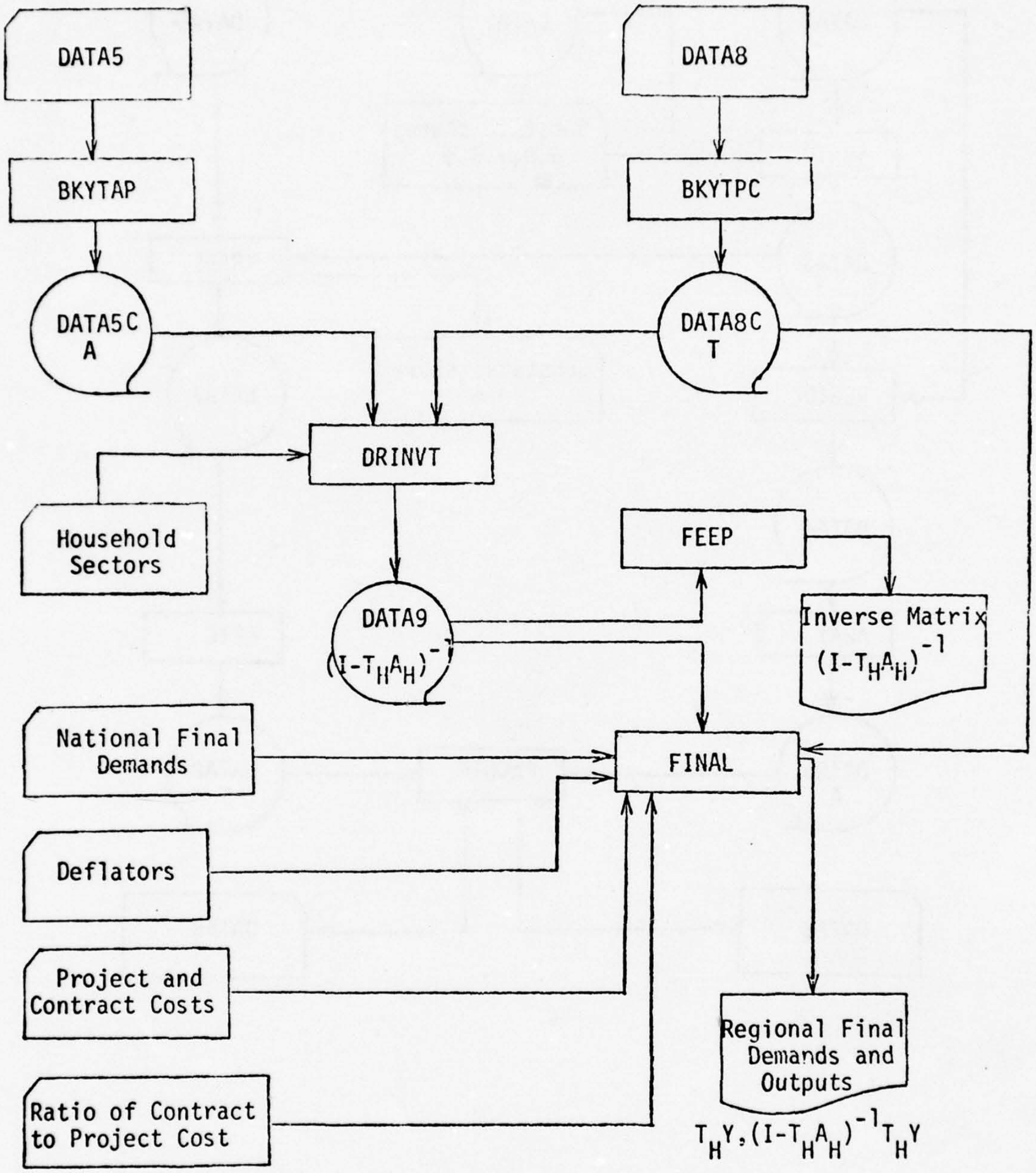

Figure 2
Flowchart for Operating Procedures
Using CDC7600 Computer for 80 Sector Model

TABLE I

Data Files on Tapes

Data Set Name	Contents	Computer	No. of Tables	Dimension	Label	Sum
DATA1	MRIO data set 1. State final demand components	UNIVAC	22	53x88	yes	yes
DATA2	MRIO data set 4. State I/O tables for 1963	UNIVAC	51	84x84	yes	yes
DATA3	Substate I/O tables	UNIVAC	4	84x84	yes	yes
DATA4	Four regional I/O tables	UNIVAC	4	84x84	yes	yes
DATA5	Technical Coefficients	UNIVAC	4	84x84	yes	yes
DATA6	MRIO data set 6. Modified commodity trade flow	UNIVAC	79	45x45	yes	yes
DATA7	Four regional trade flow	UNIVAC	79	5x5	yes	yes
DATA8	Trade Coefficients	UNIVAC	79	4x4	yes	no
DATA9	Inverse matrix tables with 16 submatrices	CDC	16	80x80	no	no
DATA5C	Technical Coefficients	CDC	4	79x79	yes	no
DATA8C	Trade Coefficients	CDC	79	4x4	yes	no

*Sum indicates the row sums and the column sums of the tables.

Table II

Data Sets on Cards

Data Set	Calling Program	Computer*	Format
Substate shares of state total receipts (α)	SUBIO(MAIN)	UNIVAC	14F5.0
Substate shares of state total receipts (β,γ,δ,ϕ)	SUBIO(MAIN)	UNIVAC	4F10.0
Substate shares of state total receipts (α)	TRADE(MAIN)	UNIVAC	14F5.2
Household sectors (80 sector model)	DRINVT(MAIN)	CDC	4F10.6
Household sectors (10 sector model)	SENFIN(MAIN)	IBM	8F10.6
National final demands in 1958	FINAL(DEMAND)	CDC	I10,7F10.2/ (5F10.2)
	SENFIN(DEMAND)	IBM	I10,7F10.2/ (5F10.2)
Deflator	FINAL(DEMAND)	CDC	5(I5,F15.2)
	SENFIN(DEMAND)	IBM	I5,F15.2
Ratio of contract cost to project cost	FINAL(CONTRC)	CDC	4F10.5
	SENFIN(CONTRC)	IBM	4F10.5
Contract cost and project cost	FINAL(CONTRC)	CDC	5F15.4
	SENFIN(CONTRC)	IBM	5F15.4

*UNIVAC: UNIVAC 1108, CDC: CDC7600, IBM: IBM S/360

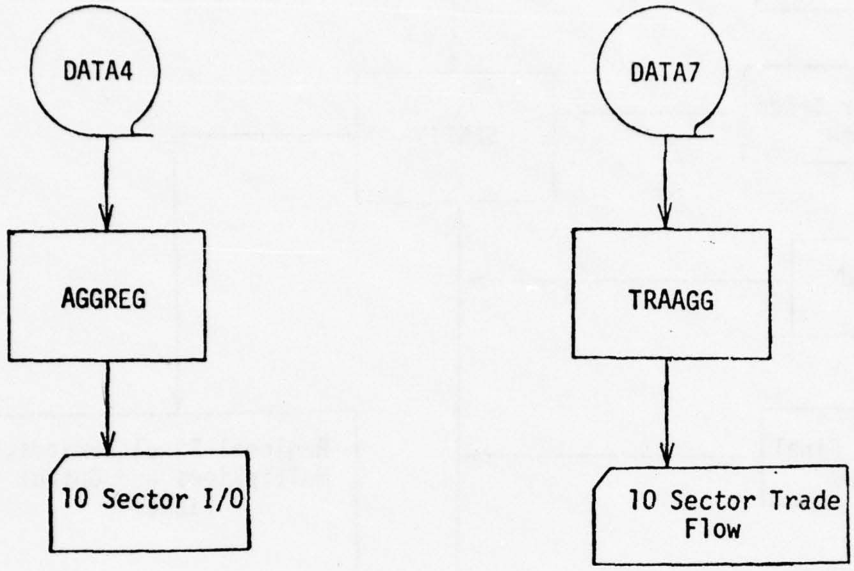

Figure 3
Flowchart for Operating Procedures
Using UNIVAC 1108 Computer for 10 Sector Model

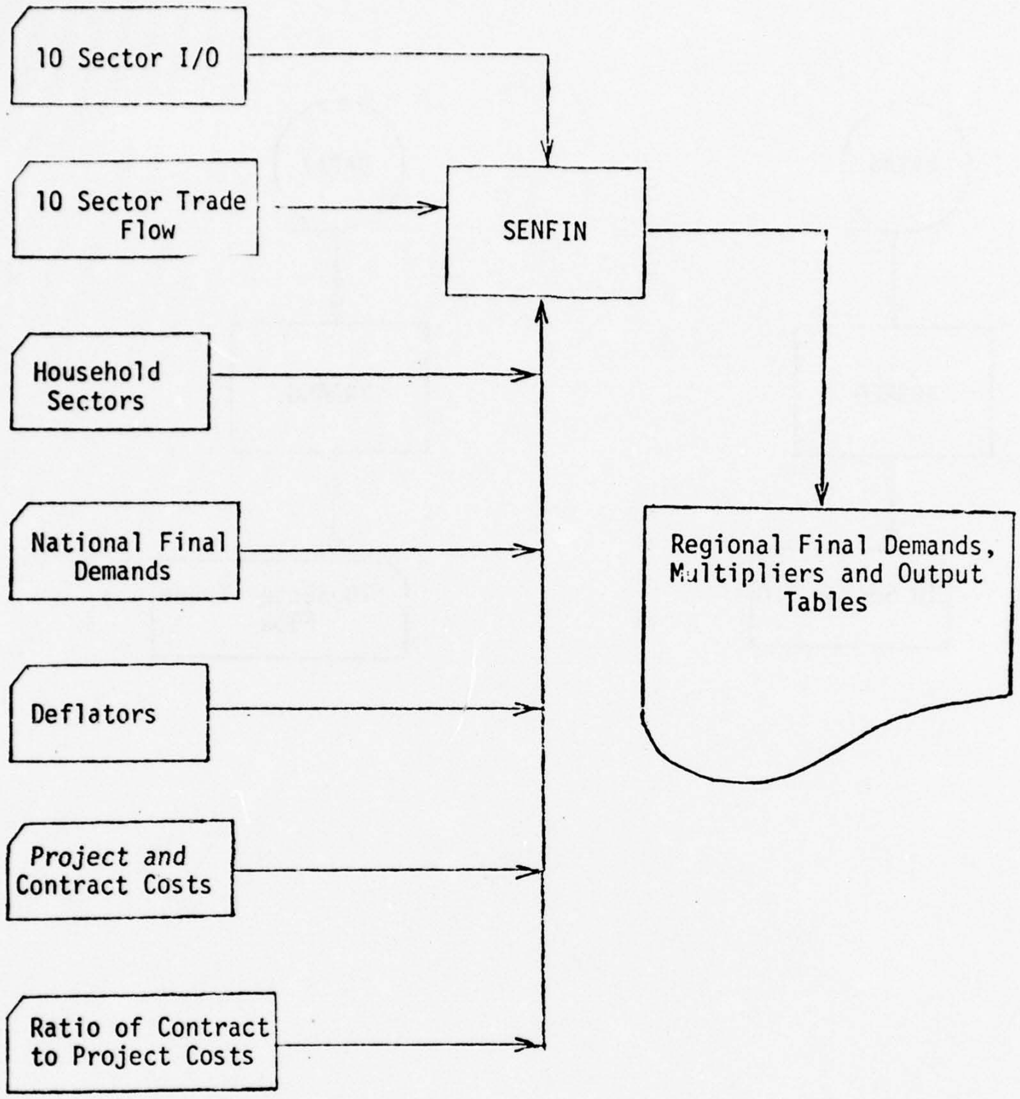

Figure 4
Flowchart for Operating Procedures
Using IBM S/360 Computer for 10 Sector Model

II. Computer Programs

A. 80 Sector Model

SUBIO

This program disaggregates the state input-output tables to make the substate input-output tables in 1963.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA1	8	input	MRIO data set 1. State final demand components.
DATA2	9	input	MRIO data set 4. 51 state input-output tables.
DATA3	7	output	Substate input-output tables.

Input Data Cards

a) Substate shares of state total receipts $(\alpha, \beta, \delta, \gamma, \phi)$

b) Title cards for labeling the tape in alphanumeric mode.

c) Control cards

NSUB: The state number for the state which is divided into two sections.

In our case,

NSUB=3 for Arkansas and 35 for Oklahoma state.

ID = 0 for one section of a state (A section)

= 1 for the other section of a state (B section)

```
@FOR,IS SUBIO,SUBIO
C*****SUBIO
C       TO MAKE SUBSTATE IO TABLES
C       7) OUTPUT FILE= DATA3
C       8) INPUT FILE = DATA2    DATA SET 4 OF MRIO
C       9) INPUT FILE = DATA1    DATA SET 1 OF MRIO
C
C
      DIMENSION LB(20)
      COMMON /P/Z(84,84),ALPHA(79),BETA,DELTA,GAMMA,PHI/Q/ID,NSUB
      DATA NR,NC,LAB/84,84,20/,NIND/79/
C
C                                        READ INPUT DATA CARDS
C
    1 READ(5,100)NSUB,ID
      IF(NSUB.EQ.0)STOP
      READ(5,200)(ALPHA(J),J=1,NIND)
      READ(5,300)BETA,DELTA,GAMMA,PHI
      READ(5,400)(LB(K),K=1,12)
C
C                                        CALL IOSUB
      CALL IOSUB
C
C                                        WRITE OUTPUT
C
      CALL NTRAN(7,1,LAB,LB,LAY,22)
      CALL NTRAN(7,1,NR*NC,Z,LAY,22)
      CALL PRINT(Z,LB)
  100 FORMAT(2I5)
  200 FORMAT(14F5.0)
  300 FORMAT(4F10.0)
  400 FORMAT(12A6)
      GO TO 1
      END
@FOR,IS IOSUB,IOSUB
C*****SUBROUTINE IOSUB
C       8) INPUT FILE = DATA2    DATA SET 4 OF MRIO
C
      SUBROUTINE IOSUB
      DOUBLE PRECISION FDX(79),DZSUM(84),DZ(84,84)
      DIMENSION IB(20),Y(84,84),COEF(79)
      COMMON /P/Z(84,84),ALPHA(79),BETA,DELTA,GAMMA,PHI/Q/ID,NSUB
      DATA NR,NC,LAB/84,84,20/,NIND/79/
      NC1=NC-1
C
C                                        READ INPUT FILE
C
      CALL NTRAN(8,10,22)
      DO 10 K=1,NSUB
      CALL NTRAN(8,2,LAB,IB,LAY,22)
      CALL NTRAN(8,2,NR*NC,Y,LAY,22)
   10 CONTINUE
C
C                                        WRITE INPUT FILE
C
      WRITE(6,400)(IB(J),J=1,20)
      WRITE(6,500)(J,Y(1,J),J=1,NC)
C                                        INITIALIZATION
      DO 15 I=1,NR
      DO 15 J=1,NC
   15 Z(I,J)=0.0
```

```
C
C                                        COMPUTE COEFFICIENTS
C
      DO 20 I=1,NR
      DO 20 J=1,NIND
      COEF(J)=ALPHA(J)/100.
      IF(ID.NE.0)COEF(J)=1.0-COEF(J)
      Z(I,J)=Y(I,J)*COEF(J)
   20 CONTINUE
      DO 25 J=81,83,2
      DO 25 I=1,NIND
   25 Z(I,J)=Y(I,J)*COEF(I)
C
C                                        CALL FDSUB
C
      CALL FDSUB(FDX)
      DO 30 I=1,NIND
   30 Z(I,82)=FDX(I)
C
C                                        CHANGE TO DOUBLE PRECISION
      DO 40 I=1,NR
      DO 40 J=1,NC
   40 DZ(I,J)=Z(I,J)
C
C                                        COLUMN SUM
C
      DO 50 I=1,NR
      DZSUM(I)=0.0
      DO 50 J=1,NC1
      DZSUM(I)=DZSUM(I)+DZ(I,J)
   50 CONTINUE
C
C                                        CHANGE TO SINGLE PRECISION
      DO 60 I=1,NR
   60 Z(I,84)=DZSUM(I)
C
C                                        WRITE OUTPUT
      WRITE(6,400)(IB(J),J=1,20)
      WRITE(6,500)(J,Z(1,J),J=1,NC)
C
  400 FORMAT(20A6)
  500 FORMAT(8(I5,F10.0))
      RETURN
      END
@FOR,IS FDSUB,FDSUB
C*****SUBROUTINE FDSUB
C     9) INPUT FILE = DATA1    DATA SET 1 OF MRIO
C
      SUBROUTINE FDSUB(FD)
      DOUBLE PRECISION FD(79),YYD(10,79)
      DIMENSION Y(53,88),IB(20),COEF(79),YY(10,79)
      COMMON /P/Z(84,84),ALPHA(79),BETA,DELTA,GAMMA,PHI/Q/ID,NS
      DATA MEHR,MSKIP,NR,NC,NIND,LAB/9,12,53,88,79,20/
C
C                                        READ INPUT FILE
C
      CALL NTRAN(9,10,22)
      DO 10 K=1,MSKIP
      IF(LAB.NE.0) CALL NTRAN(9,2,LAB,IB,LAY,22)
      CALL NTRAN(9,2,NR*NC,Y,LAY,22)
   10 CONTINUE
```

```
      DO 20 KK=1,MEHR
      IF(LAB.NE.0)CALL NTRAN(9,2,LAB,IB,LAY,22)
      CALL NTRAN(9,2,NR*NC,Y,LAY,22)
C
C                                     CHECK  INPUT FILE  BY WRITING
C
      WRITE(6,400)(IB(J),J=1,20)
      WRITE(6,500)(J,Y(NSUB,J),J=1,NC)
C
C                                     COMPUTE NEW VALUES OF COMPONEN
C
      DO 30 J=1,NIND
      IF(KK.EQ.1)COEF(J)=GAMMA/100.
      IF(KK.EQ.2.OR.KK.EQ.3)COEF(J)=BETA/100.
      IF(KK.EQ.4 )COEF(J)=ALPHA(J)/100.
      IF(KK.EQ.5.OR.KK.EQ.6.OR.KK.EQ.7)COEF(J)=DELTA/100.
      IF(KK.EQ.8.OR.  KK.EQ.9)COEF(J)=PHI/100.
      YY(KK,J)=Y(NSUB,J)*COEF(J)
      IF(ID.NE.0)YY(KK,J)=Y(NSUB,J)*(1.-COEF(J))
   30 CONTINUE
      WRITE(6,500)(M,YY(KK,M),M=1,10)
C
C                                     CHANGE TO DOUBLE PRECISION
C
      DO 40 J=1,NIND
   40 YYD(KK,J)=YY(KK,J)
   20 CONTINUE
C
C                                     FINAL DEMAND VECTOR
C
      DO 50 I=1,NIND
      FD(I)=0.0
      DO 50 KK=1,MEHR
   50 FD(I)=FD(I)+YYD(KK,I)
C
C                                     WRITE OUTPUT
C
      WRITE(6,600)
      WRITE(6,700)(I,FD(I), I=1,NIND)
C
  400 FORMAT(20A6)
  500 FORMAT(8(I5,E10.4))
  600 FORMAT(1H1,5X,'FINAL DEMAND VECTOR'/)
  700 FORMAT(8(I5,D10.4))
      RETURN
      END
@FOR,IS PRINT,PRINT
C*****SUBROUTINE PRINT
C
      SUBROUTINE PRINT(X,IB)
      DIMENSION X (84,84),IB(20)
      IS=1
      ISI=9
      N=84
      NHALF=N/2
      NPLUS=NHALF+1
      M=9
      DO 10 KK=1,M
      IT=IS+ISI
      IF(KK.EQ.M)IT=N
      WRITE(6,50)
```

```
      WRITE (6,100)(IB(I),I=1,20)
      WRITE(6,200)(I,I=IS,IT)
      DO 20 J=1,NHALF
   20 WRITE(6,300)J,(X(J,I),I=IS,IT)
      WRITE(6,200)(I,I=IS,IT)
      WRITE(6,50)
      WRITE(6,100)(IB(I),I=1,20)
      WRITE(6,200)(I,I=IS,IT)
      DO 30 J=NPLUS,N
   30 WRITE(6,300)J,(X(J,I),I=IS,IT)
      WRITE(6,200)(I,I=IS,IT)
      IS=IT+1
   10 CONTINUE
   50 FORMAT(1H1,//'TRANSACTION TABLE' /)
  100 FORMAT(1X,20A6)
  200 FORMAT(/  10I11/ )
  300 FORMAT(I5,10F11.0)
      RETURN
      END
```

REGIO

This program aggregates the MRIO state input-output tables plus the substate input-output tables into regional input-output tables.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA2	8	input	MRIO data set 4. 51 state I/O tables
DATA3	7	input	Substate I/O tables
DATA4	11	output	Regional I/O tables

Input Data Cards:

a) Title cards for labeling the tape.

b) Control cards

IREG: The identification number of the region.
Last card of the deck must be IREG=999 to terminate the processing.

NSTATE: State identification number. If NSTATE is 1000, the aggregation is terminated for a given region. Substate identification number should be greater than 52.

```
@FOR,IS REGIO,REGIO
C*****REGIO
C
C       TO MAKE REGIONAL IO TABLES
C       7) INPUT FILE = DATA3    OUTPUT OF SUBIO
C       8) INPUT FILE = DATA2    DATA SET 4 OF MRIO
C       11)OUTPUT FILE= DATA4
C
        DOUBLE PRECISION  DY(84,84),DYS(84,84)
        DIMENSION IB(20),LB(20),Y(84,84)
        DATA NR,NC,LAB/84,84,20/
C
C                                                      READ INPUT CARDS
C
      1 READ(5,100)IREG
        READ(5,150)(LB(K),K=1,12)
        IF( IREG.EQ.999) STOP
C
C                                                      INITIALIZATION
        DO 10 I=1,NR
        DO 10 J=1,NC
     10 DYS(I,J)=0.0
C
C                                                      READ INPUT FILES
C
     15 READ(5,100)NSTATE
        IF(NSTATE.EQ.1000)GO TO 45
        IF(NSTATE.LE.52)GO TO 16
        CALL NTRAN(7,10,22)
        DO 25 KK=53,NSTATE
        CALL NTRAN(7,2,LAB, IB,LAY,22)
        CALL NTRAN(7,2,NR*NC,Y,LAY,22)
     25 CONTINUE
        GO TO 21
16      CALL NTRAN(8,10,22)
        DO 20  KK=1,NSTATE
        CALL NTRAN(8,2,LAB,IB,LAY,22)
        CALL NTRAN(8,2,NR*NC,Y,LAY,22)
     20 CONTINUE
C
C                                                      WRITE  INPUT FILE
21      WRITE(6,300)NSTATE
```

```
      WRITE(6,400)(IB(J),J=1,20)
      WRITE(6,500)(J,Y(1,J),J=1,NC)
C
C                                  AGGREGATION
C
      DO 30 I=1,NR
      DO 30 J=1,NC
   30 DY(I,J)=Y(I,J)
      DO 40 I=1,NR
      DO 40 J=1,NC
   40 DYS(I,J)=DYS(I,J)+DY(I,J)
      GO TO 15
C
   45 DO 50 I=1,NR
      DO 50 J=1,NC
   50 Y(I,J)=DYS(I,J)
C
C                                                  RITE OUTPUT FILE
C
C     CALL NTRAN(11,1,LAB,LB,LAY,22)
C     CALL NTRAN(11,1,NR*NC,Y,LAY,22)
      WRITE(6,600)IREG

      CALL PRINT(Y,LB)
  100 FORMAT(I5)
  150 FORMAT(12A6)
  300 FORMAT(1H1,5X' STATE =',I5/)
  400 FORMAT(20A6)
  500 FORMAT(8(I5,E10.4))
  600 FORMAT(5X,'REGION =', I5/)
      GO TO 1
      END
```

AHAT

The A-coefficients (technical coefficients) are calculated from the regional I/O tables by this program.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA4	9	input	Regional I/O tables
DATA5	10	output	Technical coefficients

Input Data Cards:

No card is needed. But the size of the structural matrices, the size of the A coefficient matrices, and the number of the regions should be stated in the DATA statement of the main program.

```
*FOR,IS AHAT,AHAT
C       THIS PROGRAM, AHAT, COMPUTES AND OUTPUTS THE DIRECT COEFFICIENTS
C       FOR EACH REGION (84 X 84)
C       9) INPUT FILE = DATA4    OUTPUT OF REGIO
C       10)OUTPUT FILE= DATA5
C       THIS PROGRAM HAS BEEN GENERALIZED SO AS TO OPERATE WITH ANY SIZE MOD
C       THREE PARAMETERS ARE NEEDED
C       FIRST- THE SIZE OF THE STRUCTURAL MATRICES
C       SECOND - THE SIZE OF THE A COEFFICIENT MATRICES
C       THIRD - THE SIZE OF THE NUMBER OF REGIONS
        DOUBLE PRECISION A(84,84),AHAT(84,84),SUMACC
        DIMENSION B(84,84),ASING(84,84)
        EQUIVALENCE (B(1,1),ASING(1,1))
        DATA NROW,NRA,NREG/84,84,4/
        MO= 6
        WRITE(MO,113)NROW,NRA,NREG
  113   FORMAT(1X,3I4)
        CALL WIEDER (NROW,NRA,NREG,A,AHAT,SUMACC,B,ASING)
        STOP
        END
*FOR,IS WIEDER,WIEDER
        SUBROUTINE WIEDER (NROW,NRA,NREG,A,AHAT,SUMACC,B,ASING)
C
C
C
        DOUBLE PRECISION A(84,84),AHAT(84,84),SUMACC
        DIMENSION B(84,84),ASING(84,84),IB(20)
        EQUIVALENCE (B(1,1),ASING(1,1))
        DATA LAB/20/


        MO=6
        KUNST=0
        NZERO=0
        NEGCOF=0
        DO 100 IREG=1,NREG
C       READ IN THE INTERINDUSTRY FLOWS AND TRANSFER TO DOUBLE PRECISION
        CALL NTRAN(9,2,LAB,IB,LAY,22)
        CALL NTRAN (9,2,NROW**2,B,LAY,22)
        WRITE(MO,99)(IB(J),J=1,LAB)
   99   FORMAT(1H1,// 20A6 //)
        DO 799 KI=1,NROW
        DO 799 KJ=1,NROW
  799   A(KI,KJ)=B(KI,KJ)
        WRITE(MO,9)   (A(1,J),J=1,5)
    9   FORMAT(1X,'A MATRIX',10D12.6)
        DO 70 J=1,NRA
        SUMACC=0
C CALCULATION COLUMN SUMS OF REGIONAL TRADE FLOW MATRIX
        LESONE = NROW - 1
        DO 20 I=1,LESONE
   20   SUMACC=SUMACC+A(I,J)
        A(NROW,J)=SUMACC
C   IF COLUMN SUM LESS THAN .5 SET INTER-INDUSTRY COEFFICIENTS=0
        IF (SUMACC.GT.0.48) GO TO 50
        DO 30 I=1,NRA
   30   AHAT(I,J)=0
        GO TO 70
C   INTER-INDUSTRY COEFFICIENT = COLUMN OF TRADE FLOW MATRIX DIVIDED
C   BY SUM OF COLUMN
```

```
   50 CONTINUE
      KUNST=KUNST+1
      DO 60 I=1,NRA
      AHAT(I,J)=A(I,J)/SUMACC
      IF(AHAT(I,J).GT.0.0)  NZERO=NZERO+1
      IF(AHAT(I,J).LT.0.0) NEGCOF=NEGCOF+1
   60 CONTINUE
   70 CONTINUE
C     TRANSFER TO SINGL PRECISION AND OUTPUT ONTO DEVICE 10
C     CALL NTRAN(10,1,LAB,IB,LAY,22)
      DO 899 I =1,NRA
      DO 899 J = 1,NRA
  899 ASING(I,J) = AHAT(I,J)
C     CALL NTRAN (10,1 ,NRA**2,ASING,LAY,22)
      WRITE(MO,1070)  IREG
 1070 FORMAT('  WROTE INDUSTRY COEFFS FOR REGION ',I3)
      WRITE(MO,11)  (A(NROW,J),J=1,10)
   11 FORMAT (1X,'SUMACC  ',10D12.6)
      WRITE(MO,13)(AHAT(1,J),J=1,7)
   13 FORMAT(1X,'AHAT',10D15.9//)
      CALL PRINTU(MO,ASING,IB)
  100 CONTINUE
      WRITE(MO,15)KUNST
   15 FORMAT(I10,3X,'COLUMNS DIVIDED THROUGH')
      WRITE(MO,16)NZERO,NEGCOF
   16 FORMAT(/I10,3X,'NONZERO-POSITIVE COEFFICIENTS AND',2X,I10,'NEGATIV
     1E COEFFICIENTS')
      RETURN
      END
@FOR,IS PRINTU,PRINTU
C*****SUBROUTINE PRINTU(IOUT,A,IB)

C     TO WRITE OUTPUT
C
      SUBROUTINE PRINTU(IOUT,A,IB)
      DIMENSION A(84,84),IB(20)
      DATA M,N,NHALF/9,84,42/,LAB/20/
      JS=1
      JSI=9
      NPLUS=NHALF+1
      DO 10 KK=1,M
      JT=JS+JSI
      IF(KK.EQ.M) JT=N
      WRITE(IOUT,50)
      WRITE(IOUT,100)(IB(I),I=1,LAB)
      WRITE(IOUT,200)(J,J=JS,JT)
      DO 20 I=1,NHALF
   20 WRITE(IOUT,300)I,(A(I,J),J=JS,JT)
      WRITE(IOUT,200)(J,J=JS,JT)
      IF(NPLUS.GT.N) GO TO 40
      WRITE(IOUT,50)
      WRITE(IOUT,100)(IB(I),I=1,LAB)
      WRITE(IOUT,200)(J,J=JS,JT)
      DO 30 I=NPLUS,N
   30 WRITE(IOUT,300) I, (A(I,J),J=JS,JT)
      WRITE(IOUT,200) (J,J=JS,JT)
C   DUMMY CONTINUE
```

```
 40 CONTINUE
    JS=JT+1
 10 CONTINUE
 50 FORMAT(1H1, // 'DIRECT REQUIREMENTS' /)
100 FORMAT(1X,20A6)
200 FORMAT(/ 10I11 /)
300 FORMAT(I5,10F11,6)
    RETURN
    END
```

TRADE

This program disaggregates the trade flows of the regions identified as 28 and 30 into two sections for each region and aggregates the resulting trade flows into the four regional trade flows.
Substate shares of the total state receipts (π) is computed by this program.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA3	7	input	Substate I/O tables
DATA6	8	input	MRIO data set 6. Modified commodity trade flow
DATA7	9	output	Regional trade flow

Input Data Cards:

a) Control cards

KK(IEX),LL(IEX): Row or column numbers of the matrix to be exchanged with each other. The rearrangement of the modified matrix with substate trade flows is carried out in a number of exchange operations.

IEXN is the total number of exchange operations.

In our case,

IEX	KK(IEX)	LL(IEX)
1	1	45
2	2	47

(continued on next page)

(continued)

IEX	KK(IEX)	LL(IEX)
3	3	46
4	4	48
5	5	29
6	6	31
7	7	11
8	8	15
9	28	47
10	30	48

M(K): the column or row number where aggregation starts.

Aggregation continues up to the column before the next M.

In our case,

1 3 7 9 47

MANIP(J)=1: for making the off-diagonal elements zeroes for service industries.

≠1: no change is made.

Only one card is needed using FORMAT(80I1).

b) Substate shares (α)

c) Title cards for labeling the tape.

```
@FOR,IS TRADE,TRADE
C*****TRADE
C
C      TO  MAKE THE TRADE FLOW TABLE OF IRIO USING MRIO DATA
C      7) INPUT FILE = DATA5    OUTPUT OF SUBIO
C      8) INPUT FILE = DATA6    DATA SET 6 OF MRIO
C      9) OUTPUT FILE= DATA7
C
       DIMENSION LL(10),MANIP(79)
       DIMENSION A(48,48),TEMP(48), KK(10), M(5),       T(5,5),AL28(79),AL3
      10(79),JB(20), IB(20),C(45,45)
       DOUBLE PRECISION SUM,SUMROW,SUMCOL
       COMMON /X/P28A(79),P28B(79),P30A(79),P30B(79)
       DATA INP,IOUT/5,6/,NIND,LAB,NREG/79,20,44/
       DATA IREGN,IREGP,IEXN,KMAX/4,48,10,5/,IREGM/5/
C
C                       READ AND WRITE MATRIX  OPERATION  GUIDE  INPUT
C
       DO 10 IEX=1,IEXN
       READ(INP,100) KK(IEX), LL(IEX)
       WRITE(IOUT,200) IEX, KK(IEX), LL(IEX)
    10 CONTINUE
       READ(INP,300) (M(K),K=1,KMAX)
       WRITE(IOUT,300)(M(K),K=1,KMAX)
       READ(INP,500)(AL28(J),J=1,NIND)
       READ(INP,500)(AL30(J),J=1,NIND)
       CALL PAI
       WRITE(IOUT,600) (J,AL28(J),J=1,NIND)
       WRITE(IOUT,600) (J,AL30(J),J=1,NIND)
       READ(INP,650)(MANIP(J),J=1,NIND)
C
       CALL NTRAN(8,10,22)
C
       DO 95 KKK=1,NIND
       AL28A=AL28(KKK)
       AL28B=1.0-AL28A
       AL30A=AL30(KKK)
       AL30B=1.0-AL30A
       PI28A=P28A(KKK)
       PI28B=P28B(KKK)
       PI30A=P30A(KKK)
       PI30B=P30B(KKK)
C
C                       READ AND WRITE INPUT FILE
C
C    DIMENSION OF MATRIX 'C' MUST BE EXACTLY THE SAME AS ORIGINALLY
C    WRITTEN DATA.
       NREGP=NREG+1
       CALL NTRAN(8,2,LAB,IB,LAY,22)
       WRITE(IOUT,700)(IB(J),J=1,LAB)
       CALL NTRAN(8,2,NREGP**2,C,LAY,22)
       WRITE(IOUT,800)(C(1,J),J=1,NREGP)
C
       DO 15 I=1,NREG
       DO 15 J=1,NREG
       A(I,J)=C(I,J)
    15 CONTINUE
```

```
C
C                          CREATE NEW ROWS AND COLUMNS
C
      DO 20 I=1,NREG
      A(I,45)=PI28A*A(I,28)
      A(I,46)=PI28B*A(I,28)
      A(I,47)=PI30A*A(I,30)
      A(I,48)=PI30B*A(I,30)
   20 CONTINUE
      DO 30 J=1,NREG
      A(45,J)=AL28A*A(28,J)
      A(46,J)=AL28B*A(28,J)
      A(47,J)=AL30A*A(30,J)
      A(48,J)=AL30B*A(30,J)
   30 CONTINUE
C
C
      A(45,45)=AL28A*PI28A*A(28,28)
      A(45,46)=AL28A*PI28B*A(28,28)
      A(45,47)=AL28A*PI30A*A(28,30)
      A(45,48)=AL28A*PI30B*A(28,30)
C
      A(46,45)=AL28B*PI28A*A(28,26)
      A(46,46)=AL28B*PI28B*A(28,28)
      A(46,47)=AL28B*PI30A*A(28,30)
      A(46,48)=AL28B*PI30B*A(28,30)
C
      A(47,45)=AL30A*PI28A*A(30,28)
      A(47,46)=AL30A*PI28A*A(30,28)
      A(47,47)=AL30A*PI30A*A(30,30)
      A(47,48)=AL30A*PI30B*A(30,30)



C
      A(48,45)=AL30B*PI28A*A(30,28)
      A(48,46)=AL30B*PI28B*A(30,28)
      A(48,47)=AL30B*PI30A*A(30,30)
      A(48,48)=AL30B*PI30B*A(30,30)
C
C     MAKE OFF-DIAGONALS ZERO FOR SERVICE INDUSTRIES
C
      IF(MANIP(KKK).NE.1)GO TO 35
      A(45,45)=A(45,45)+A(46,45)
      A(46,45)=0.0
      A(46,46)=A(46,46)+A(45,46)
      A(45,46)=0.0
      A(47,47)=A(47,47)+A(48,47)
      A(48,47)=0.0
      A(48,48)=A(48,48)+A(47,48)
      A(47,48)=0.0
   35 IF(KKK.GT.3)GO TO 45
C
C                          WRITE ALL THE MATRIX ELEMENTS BEFORE INTERCHANGE
C
      WRITE(IOUT,900) KKK
      CALL OUTPUT(IOUT,A,KKK)
```

```
C
C                          INTERCHANGE OF ROWS AND COLUMNS
C
   45 DO 60 IEX=1,IEXN
      IK=KK(IEX)
      IL=LL(IEX)
      DO 40 J=1,IREGP
      TEMP(J)=A(IK,J)
      A(IK,J)=A(IL,J)
      A(IL,J)=TEMP(J)
   40 CONTINUE
      DO 50 I=1,IREGP
      TEMP(I)=A(I,IK)
      A(I,IK)=A(I,IL)
      A(I,IL)=TEMP(I)
   50 CONTINUE
   60 CONTINUE
C
C                          WRITE MATRIX AFTER CHANGE
C
      IF(KKK.GT.3)GO TO 65
      WRITE(IOUT,1000) KKK
      CALL OUTPUT(IOUT,A,KKK)
C
C                          AGGREGATION
C
   65 DO 80 K=1,IREGN
      DO 80 L=1,IREGN
      IPL=M(K+1)-1
      IRL=M(L+1)-1
      IPS=M(K)
      IRS=M(L)
      SUM=0.0
      DO 70 I=IPS,IPL
      DO 70 J=IRS,IRL
      SUM=SUM+A(I,J)
   70 CONTINUE
      T(K,L)=SUM


   80 CONTINUE
C
C                   SUMMATION
C
      DO 85 L=1,IREGN
      SUMCOL=0.0
      DO 84 K=1,IREGN
   84 SUMCOL=SUMCOL+T(K,L)
   85 T(IREGM,L)=SUMCOL
      DO 87 L=1,IREGM
      SUMROW=0.0
      DO 86 K=1,IREGN
   86 SUMROW=SUMROW+T(L,K)
   87 T(L,IREGM)=SUMROW
```

```
C                              WRITE OUTPUT FILE
C
      READ(INP,701)(JB(I),I=1,14)
      WRITE(IOUT,701)(JB(I),I=1,LAB)
      DO 90 K=1,IREGM
   90 WRITE(IOUT,400)(T(K,L),L=1,IREGM)
      CALL NTRAN(9,1,LAB,JB,LAY,22)
      CALL NTRAN(9,1,IREGM**2,T,LAY,22)
   95 CONTINUE
C
C
  100 FORMAT(2I5)
  200 FORMAT(///3I10)
  300 FORMAT(5I5)
  400 FORMAT(5E20.4)
  500 FORMAT(14F5.2)
  600 FORMAT(8(I5,F10.4))
  650 FORMAT(80I1)
  700 FORMAT(///20A6)
  701 FORMAT(13A6,A2)
  800 FORMAT(8E15.4)
  900 FORMAT(///10X,'MATRIX BEFORE CHANGE FOR INDUSTRY =',I5)
 1000 FORMAT(///10X,'MATRIX AFTER CHANGE FOR INDUSTRY =',I5)
 1100 FORMAT(1H1)
      STOP 0000
      END
@FOR,IS OUTPUT,OUTPUT
      SUBROUTINE OUTPUT(IOUT,A,IND)
      DIMENSION A(48,48)
      JS=1
      JSI=9
      N=48
      M=5
      DO 10 KK=1,M
      JT=JS+JSI
      IF(KK.EQ.M) JT=N
      WRITE(IOUT,100) IND
      WRITE(IOUT,200) (J,J=JS,JT)
      DO 20 I=1,N
   20 WRITE(IOUT,300) I,(A(I,J),J=JS,JT)
      WRITE(IOUT,200) (J, J=JS,JT)
      JS=JT+1
   10 CONTINUE
  200 FORMAT(/10I11/)
  300 FORMAT(I5,10E11.5)
  100 FORMAT(1H1,5X,'INDUSTRY =',I5)

      RETURN
      END
```

```
@FOR,IS PAI,PAI
      SUBROUTINE PAI
      COMMON /X/P28A(79),P28B(79),P30A(79),P30B(79)
      DIMENSION A(84,84),IB(20),PAI28A(79),PAI28B(79),PAI30A(79),
     1 PAI30B(79)
      DATA LAB,NR,NC,NIND,IOUT/20,84,84,79,6/
C     7) INPUT FILE = DATAS   OUTPUT OF SUBIO
      CALL NTRAN(7,10,22)
      DO 30 K=1,4
      CALL NTRAN(7,2,LAB,IB,LAY,22)
      WRITE(IOUT,700)(IB(J),J=1,LAB)
      CALL NTRAN(7,2,NR*NC,A,LAY,22)
      WRITE(IOUT,800)(A(1,J),J=1,NC)
      DO 20 I=1,NIND
      IF(K.EQ.1)PAI28A(I)=A(I,84)
      IF(K.EQ.2)PAI28B(I)=A(I,84)
      IF(K.EQ.3)PAI30A(I)=A(I,84)
      IF(K.EQ.4)PAI30B(I)=A(I,84)
   20 CONTINUE
   30 CONTINUE
      CALL NTRAN(7,10,22)
C
C     REDEFINE ROWSUMS FOR INDUSTRY 74 TO PREVENT OVERFLOW
C         PAI28(74) = PAI30(74) = 0.0
C
      PAI28A(74)=1.0
      PAI28B(74)=1.0
      PAI30A(74)=1.0
      PAI30B(74)=1.0
      DO 40 I=1,NIND
      P28A(I)=PAI28A(I)/(PAI28A(I)+PAI28B(I))
      P28B(I)=PAI28B(I)/(PAI28A(I)+PAI28B(I))
      P30A(I)=PAI30A(I)/(PAI30A(I)+PAI30B(I))
      P30B(I)=PAI30B(I)/(PAI30A(I)+PAI30B(I))
      WRITE(IOUT,900)I,P28A(I),P28B(I),P30A(I),P30B(I)
   40 CONTINUE
  700 FORMAT(1H1,20A6)
  800 FORMAT(8E15.4)
  900 FORMAT(I10,4F20.4)
      RETURN
      END
```

GETC

This program calculates the column coefficients from the trade flow tables by dividing all elements in the column by the column sum.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA4	11	input	Regional I/O tables
DATA7	9	input	Regional trade flows
DATA8	10	output	Trade coefficients

Data Cards:

Title cards for tape labeling.

```
@FOR,IS GETC,GETC
C*****GETC
C                   COMPUTES 4 REGION TRADE COEFFICIENTS
C
C      TO GENERATE TRADE COEFFICIENTS USING OUTPUTS OF REGIO AND TRADE
C      ALTERNATIVE METHOD DOES NOT NEED OUTPUTS OF REGIO
C
C      9) INPUT FILE = DATA7    OUTPUT OF TRADE
C      10)OUTPUT FILE= DATA8
C      11)INPUT FILE = DATA4    OUTPUT OF REGIO
C
      INTEGER G,H
      DOUBLE PRECISION SUMROW, SUMCOL, SUMCOE, C
      LOGICAL NOTRAN,ALTER
      DIMENSION IB(20),Y(84,84),XH(83,4),XG(4,83),XOH(79,4),XGO(4,79),
     1C(4,4),T(5,5),XGH(4,4),CSING(4,4),JB(20)
      DATA NR,NC,LAB/84,84,20/,IREG,NIND/4,79/,INP,IOUT/5,6/,IREGP/5/
      DATA NOTRAN/.FALSE./,ALTER/.FALSE./


C
C        ALTER=.TRUE. IF ALTERNATIVE METHOD IS USED
C
      IF(ALTER) GO TO 45
C
C               NOTRAN=.TRUE. IF TRANSFER-OUT IS SUBTRACTED
C
      M1=NR-1
C
C               M1 ALSO REPRESENTS THE TRANSFERS-OUT COLUMN
C
      DO 30 KK=1,IREG
C
C               READ AND WRITE  INPUT FILE FOR INDUSTRIAL FLOW
C
      CALL NTRAN(11,2,LAB,IB,LAY,22)
      CALL NTRAN(11,2,NR*NC,Y,LAY,22)
      WRITE(IOUT,700)(IB(J),J=1,LAB)
      WRITE(IOUT,800)(Y(1,J),J=1,NC)
      DO 20 I=1,M1
      SUMROW=0.0
      SUMCOL=0.0
C
C               SUMMATION
C
      DO 10 J=1,M1
      SUMROW=SUMROW+Y(I,J)
      SUMCOL=SUMCOL+Y(J,I)
   10 CONTINUE
      IF(NOTRAN) SUMROW=SUMROW-Y(I,M1)
      IF(NOTRAN) SUMCOL=SUMCOL-Y(M1,I)
      XH(I,KK)=SUMROW
      XG(KK,I)=SUMCOL
   20 CONTINUE
   30 CONTINUE
```

```
C
      DO 40 I=1,IREG
      DO 40 J=1,NIND
      XGO(I,J)=XG(I,J)
      XOH(J,I)=XH(J,I)
   40 CONTINUE
      WRITE(IOUT,900)
      WRITE(IOUT,800) (XGO(1,J),J=1,NIND)
      WRITE(IOUT,800) (XOH(1,J),J=1,IREG)
C
C                READ AND WRITE  REGIONAL TRADE FLOW
C
   45 DO 150 INDUS=1,NIND
      CALL NTRAN(9,2,LAB,IB,LAY,22)
      CALL NTRAN(9,2,IREGP**2,T,LAY,22)
C     WRITE(IOUT,700) (IB(J),J=1,LAB)
C     WRITE(IOUT,400) (T(1,J),J=1,IREGP)
C
      DO 50 I=1,IREG
      DO 50 J=1,IREG
   50 XGH(I,J)=T(I,J)
C
C                SET COEFFICIENT MATRIX TO IDENTITY MATRIX
      DO 60  J=1,IREG
      DO 60  I=1,IREG
   60 C(I,J)=0.0


      DO 70 I=1,IREG
   70 C(I,I)=1.0
      DO 80 H=1,IREG
      DO 80 G=1,IREG
C
C                IF CONSUMPTION CONTROL LESS THAN 0.5 COEFFICIENT NOT
C                CALCULATED 1 IS LEFT IN THE DIAGONAL ENTRY. THE REST OF
C                THE COLUMN IS ZERO.
C
      IF(XOH(INDUS,H).LT.0.5) GO TO 80
C
C                COLUMN COEFFICIENTS = COLUMN OF TRADE MATRIX DIVIDED BY
C                ROW SUMS OF REGIONAL I-O TABLES
C
      IF(.NOT.ALTER) GO TO 75
C
C         COLUMN SUM IS USED
C         IN PLACE OF ROW SUMS
C         OF REGIONAL IO TABLES
      XOH(INDUS,H)=T(IREGP,H)
C
   75 C(G,H)=XGH(G,H)/XOH(INDUS,H)
   80 CONTINUE
C
C                CORRECTING COLUMN SUM TO ADD TO 1
C
      DO 120 H=1,IREG
      SUMCOE=0.0
      DO 90 G=1,IREG
   90 SUMCOE=SUMCOE+C(G,H)
```

PNCHTP

Punched cards of the A coefficients and the T coefficients of the 80 sector model are obtained by this program.

The technical coefficients have a dimension of 79x79.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA5	8	input	Technical coefficient tables (84x84)
DATA8	7	input	Trade coefficient tables (4x4)

Input Data Cards:

No input data card is necessary, but the necessary values should be given in the DATA statements for the following variables:

NRA: the size of the input matrix

NIND: the size of the output matrix

IREG: the number of regions

KEY1,KEY2,KEY3: the control keys.

```
@FOR,IS PNCHTP,PNCHTP
      DIMENSION C(4,4), A(84,84), AHAT(79,79), JB(20)
      DIMENSION IC(16),IAHAT(79)
      DATA KEY1,KEY2,KEY3/0,1,4/
      DATA NRA,NIND /84,79/
      DATA IREG,LAB / 4,20/
      NCOUNT = NIND**2
      MCOUNT = NRA**2
      LCOUNT = IREG**2
      IF(KEY1.EQ.0)GO TO 55
C
C   READ TRADE COEFFICIENTS.
C
      DO 50 IND=1,NIND
C
      CALL NTRAN(7,2,LAB,JB,LAY,22)
      IF(MOD(IND-1,10).NE.0)GO TO 25
      WRITE(6,1000)JB
 1000 FORMAT(1X,20A6)
      WRITE(1,1001)(JB(I),I=1,13)
 1001 FORMAT(13A6)
C
   25 ICOUNT=0
      CALL NTRAN(7,2,LCOUNT,C,LAY,22)
      DO 30 I=1,IREG
      DO 30 K=1,IREG
      ICOUNT=ICOUNT+1
   30 IC(ICOUNT)=C(I,K)*10000
   50 WRITE(1,1002)IC
 1002 FORMAT(16I5)
C
   55 IF(KEY2.EQ.0)GO TO 110
C
C   READ TECHNICAL COEFFICIENTS.
C
      DO 100 K=1,IREG
      CALL NTRAN(8,2,LAB,JB,LAY,22)
      WRITE(6,1000)JB
      WRITE(1,1001)(JB(I),I=1,13)
C
C
      CALL NTRAN(8,2,MCOUNT,A,LAY,22)
C
      IF(K.LT.KEY3)GO TO 100
C
      DO 60 I=1,NIND
      DO 60 J=1,NIND
   60 AHAT(I,J) = A(I,J)
C
      DO 70 I=1,NIND
      DO 65 J=1,NIND
   65 IAHAT(J)=AHAT(I,J)*10000
   70 WRITE(1,1002)I,IAHAT
C
      IF(K.EQ.KEY3)GO TO 110
  100 CONTINUE
C
C
  110 STOP 0000
C   THIS IS THE
      END
```

BKYTAP

This program creates the files of A coefficients on a tape in the CDC system using the input data cards.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA5C*	8	output	Technical coefficients (79x79)

Input Data Cards:

a) Title cards

b) A coefficient data cards punched by the UNIVAC system.

*DATA5C is the same data set as DATA5 except that DATA5C does not contain value added, transfer-in, transfer-out, final demand vector, column sum and row sum.

```
      PROGRAM BKYTAP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAP;
      DIMENSION IA(79),AHAT(79,79)
      DIMENSION IB(16)
      DATA NREG, NIND /4,79 /
      DATA KEV,KREG,MREG/0,3,2/
      DATA IREG /1/
C
   10 IF(KEY.GE.KREG)GO TO 15
C
      READ(7)IREG
      READ(7)AHAT
      WRITE(8)IREG
      WRITE(8)AHAT
      WRITE(6,1005)
 1005 FORMAT(1X,10HPREV, TAPE)
      WRITE(6,1003)IREG
 1003 FORMAT(1H0,7H REGION,I5,// )
      IND=1
      WRITE(6,1004)IND
      WRITE(6,1002)(AHAT(IND,J),J=1,NIND)
      IND=79
      WRITE(6,1004)IND
      WRITE(6,1002)(AHAT(IND,J),J=1,NIND)
      KEY =KEY+1
      GO TO 10
C
C
C
   15 READ(5,1014) IB
 1014 FORMAT(16A5)
      WRITE(6,1015) IB
 1015 FORMAT(1H0,16A5)
C
      DO 100 IND =1,NIND
      READ(5,1000) II,IA
 1000 FORMAT(16I5)
C
      IF(II.EQ.IND)GO TO 20
C
      WRITE(6,1001)II,IA
 1001 FORMAT(1X,16I5)
      STOP 7777
C
   20 DO 40 J=1,NIND
   40 AHAT(IND,J) = IA(J)/10000.
C
      IF(IND.GT.1.AND.IND.LT.NIND)GO TO 100
C
      WRITE(6,1004)IND
 1004 FORMAT(6H0IND =,I5)
C
      WRITE(6,1002)(AHAT(IND,J),J=1,NIND)
 1002 FORMAT(10(1X,E11.5))
```

```
C
C
  100 CONTINUE
C
C
C
      IREG=KEY+1
      WRITE(6,1003)IREG
      WRITE(6,1006)
 1006 FORMAT(1X,8HNEW TAPE)
C
C
      WRITE(8)IREG
C
      WRITE(8)AHAT
C
      IREG = IREG +1
      IF(IREG.LT.MREG)GO TO 15
C
      STOP 0000
C   THIS IS THE
      END
```

BKYTPC

This program creates the files of T coefficients on a tape in the CDC system using the input data cards.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA8C	8	output	Trade coefficients (4x4)

Input Data Cards:

a) Title cards

b) T coefficient data cards punched by the UNIVAC system.

```
      PROGRAM BKYTPC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE8)
      DIMENSION IB(16),IC(4,4),C(4,4)
      DATA NIND,NREG /79,4/
C
C
      DO 100 IND=1,NIND
      IF(MOD(IND-1,10).NE.0)GO TO 10
      READ(5,1000)IB
 1000 FORMAT(16A5)
      WRITE(6,1001)IB
 1001 FORMAT(1X,16A5)
C
   10 READ(5,1002)IC
 1002 FORMAT(16I5)
C
      DO 20 I=1,NREG
      DO 20 J=1,NREG
   20 C(I,J) = IC(I,J)/10000.
C
      IF(MOD(IND-1,10).NE.0)GO TO 100
C
      WRITE(6,1003)
 1003 FORMAT(2H0 )
      WRITE(6,1004)C
 1004 FORMAT(11X,4F10.4)
      WRITE(6,1003)
C
  100 WRITE(8)C
C
      END FILE 8
      END FILE 8
      END FILE 8
      END FILE 8
      STOP 0000
C   THIS IS THE
      END
```

DRINVT

This program calculates the direct requirements, $T_H A_H$ and the direct and indirect and induced requirements (the inverse matrix), $(I-T_H A_H)^{-1}$ with the household sector coefficients. The inverse matrix is obtained using a subprogram, INVERT, which is adapted from the BMDO3R program. The modified Gauss-Jordan reduction method, or the maximum pivot strategy is utilized in the subroutine, INVERT. With this subroutine, the inversion is carried out in place.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA5C	11	input	Technical coefficients (75x75)
DATA8C	12	input	Trade coefficients (4x4)
DATA9	14	output	Inverse matrix consisted of 16 submatrices

Input Data Cards:

Household sector coefficients for rows and columns

```
      PROGRAM DRINVT(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE11,
     1 TAPE12,TAPE13,TAPE14)
C*****DRINVT
C
C         TO OBTAIN DIRECT REQUIREMENTS AND DIRECT AND INDIRECT AN
C         INDUCED REQUIREMENTS FOR 79 SECTOR I-O MODEL  WITH HOUS
C         NUMBER OF REGION IS FOUR.
C
C         11) INPUT FILE & AHAT-DATA5
C         12) INPUT FILE & GETC-DATA3
C         13) OUTPUT FILE& STEP1-DATA              I-TA             & TAPE1
C         14) OUTPUT FILE& STEP2-DATA9             (I-TA)(-1)       & TAPE2
C
C
      LARGE E(320,320)
      LARGE A(4,80,80), F(80,80), G(80,80), AHAT(79,79)
      DIMENSION  C(4,4), T(4,4,80), MKP(320), LKP(320)
C
C
      LOGICAL TAPE1, TAPE2
      DATA NREG,NIND/4,79/
      DATA TAPE1,TAPE2/.FALSE.,.TRUE./
      DATA ISTEP/2/
      INP=5
      IOUT=6
      NREGP=NREG+1
      NINDP=NIND+1
      IMAXP=NREG*NINDP
C
C         FIRST STEP
C
C         READ TECHNICAL COEFFICIENTS
C
      DO 20 IREG=1,NREG
      READ(11) KREG
      WRITE(6,1000)IREG,KREG
 1000 FORMAT(1X,2I5)
      READ(11) AHAT
      DO 10 I=1,NIND
      DO 10 J=1,NIND
   10 A(IREG,I,J)=AHAT(I,J)
   20 CONTINUE
C
C         READ CARDS FOR HOUSEHOLD
C
      DO 30 I=1,NINDP
   30 READ(INP,101)(A(IREG,I,NINDP),IREG=1,NREG)
      DO 40 J=1,NINDP
   40 READ(INP,101)(A(IREG,NINDP,J),IREG=1,NREG)
C
C         READ TRADE COEFFICIENTS
C
      DO 60 IND=1,NIND
      READ(12) C
      DO 50 L=1,NREG
      DO 50 K=1,NREG
```

```
   50 T(K,L,IND)= C(L,K)
   60 CONTINUE
C
C          HOUSE-HOLD  SECTOR FOR TRADE COEFFICIENTS
C
      DO 70 L=1,NREG
      DO 70 K=1,NREG
   70 T(K,L,NINDP)=0.0
      DO 80 K=1,NREG
   80 T(K,K,NINDP)=1.0
C
C          CHECK INPUT DATA
C
      DO 90 IREG=1,NREG
      WRITE(IOUT,201) (A(IREG,1,J),J=1,NINDP)
      WRITE(IOUT,201) (A(IREG,NINDP,J),J=1,NINDP)
      WRITE(IOUT,301)
      WRITE(IOUT,201) (T(IREG,IREG,J),J=1,NINDP)
   90 CONTINUE
C
C          COMPUTE T*A
C
      DO 100 L=1,NREG
      DO 100 K=1,NREG
      DO 100 J=1,NINDP
      DO 100 I=1,NINDP
      KK=NINDP*(K-1)+I
      LL=NINDP*(L-1)+J
      E(KK,LL)=T(K,L,I)*A(L,I,J)
  100 CONTINUE
C
C
      WRITE(6,1001)
 1001 FORMAT(1H1)
C
C          WRITE  T*A
C
      DO 130 K=1,NREG
      DO 130 L=1,NREG
      DO 110 J=1,NINDP
      DO 110 I=1,NINDP
  110 F(I,J)=0.0
      DO 120 I=1,NINDP
      DO 120 J=1,NINDP
      KK=NINDP*(K-1)+I
      LL=NINDP*(L-1)+J
  120 F(I,J)=E(KK,LL)
C
C     CALL PRINTE(F,NINDP,NINDP,K,L,IOUT,1)
      CALL PRINTF(K,L)
  130 CONTINUE
C
C          COMPUTE  I-TA
C
      DO 150 LL=1,IMAXP
      DO 140 KK=1,IMAXP
```

```
      IF(KK.NE.LL)E(KK.LL)=-E(KK.LL)
      IF(KK.EQ.LL) E(KK.LL)=1.0-E(KK.LL)
  140 CONTINUE
      IF(TAPE1) WRITE(13)E
  150 CONTINUE
      IF(ISTEP.EQ.1) GO TO 999
C
C          SECOND STEP
C
C          INVERSION OF MATRIX  I-TA
C
      CALL INVERT(E,IMAXP,LKP,MKP)
      DO 180 K=1,NREG
      DO 180 L=1,NREG
      DO 160 J=1,NINDP
      DO 160 I=1,NINDP
  160 G(I.J)=0.0
      DO 170 I=1,NINDP
      DO 170 J=1,NINDP
      KK=NINDP*(K-1)+I
      LL=NINDP*(L-1)+J
  170 G(I.J)=E(KK,LL)
      CALL PRINTE(G,NINDP,NINDP,K,L,IOUT,2)
      IF(TAPE2) WRITE(14)G
  180 CONTINUE
C
  101 FORMAT(4F10.6)
  201 FORMAT(5G20.5)
  301 FORMAT(///)
  999 STOP 0000
      END
```

```
      SUBROUTINE INVERT (A,N,L,M)
C*****INVERT
C           SUBROUTINE INVERT FOR BMD03R
C     PROGRAM FOR FINDING THE INVERSE OF A NXN MATRIX
      LARGE A(320,320)
      DIMENSION L(320), M(320)
C     SEARCH FOR LARGEST ELEMENT
C
      D=1.
      DO 80 K=1,N
      MODD=(K/10)*10-K
      IF(MODD.EQ.0)WRITE(6,1000)K
 1000 FORMAT(6H INVRT,I5)
      L(K)=K
      M(K)=K
      BIGA=A(K,K)
      DO 20 I=K,N
      DO 20 J=K,N
      IF(ABS(BIGA)-ABS(A(I,J))) 10,20,20
   10 BIGA=A(I,J)
      L(K)=I
      M(K)=J
   20 CONTINUE
C     INTERCHANGE ROWS
      J=L(K)
      IF(L(K)-K) 35,35,25
   25 DO 30 I=1,N
      HOLD=-A(K,I)
      A(K,I)=A(J,I)
   30 A(J,I)=HOLD
C     INTERCHANGE COLUMNS
   35 I=M(K)
      IF(M(K)-K) 45,45,37
   37 DO 40 J=1,N
      HOLD=-A(J,K)
      A(J,K)=A(J,I)
   40 A(J,I)=HOLD
C     DIVIDE COLUMNS BY MINUS PIVOT
   45 DO 55 I=1,N
   46 IF(I-K)50,55,50
   50 A(I,K)=A(I,K)/(-A(K,K))
   55 CONTINUE
C     REDUCE MATRIX
      DO 65 I=1,N
      DO 65 J=1,N
   56 IF(I-K) 57,65,57
   57 IF(J-K) 60,65,60
   60 A(I,J)=A(I,K)*A(K,J)+A(I,J)
   65 CONTINUE
C     DIVIDE ROW BY PIVOT
      DO 75 J=1,N
   68 IF(J-K)70,75,70
   70 A(K,J)=A(K,J)/A(K,K)
   75 CONTINUE
C     CONTINUED PRODUCT OF PIVOTS
      D=D*A(K,K)
```

```
C       REPLACE PIVO  BY RECIPROCAL
        A(K,K)=1.0/A(K,K)
   80 CONTINUE
C       FINAL ROW AND COLUMN INTERCHANGE
        K=N
  100 K=(K-1)
        IF(K) 150,150,103
  103 I=L(K)
        IF(I-K) 120,120,105
  105 DO 110 J=1,N
        HOLD=A(J,K)
        A(J,K)=-A(J,I)
  110 A(J,I)=HOLD
  120 J=M(K)
        IF(J-K) 100,100,125
  125 DO 130 I=1,N
        HOLD=A(K,I)
        A(K,I)=-A(J,I)
  130 A(J,I)=HOLD
        GO TO 100
  150 RETURN
        END


        SUBROUTINE PRINTE(A,NROW,NCOL,NROWS,NCOLS,IOUT,ID)
C$$$$$SUBROUTINE PRINTE
C
C
C         TO PRINT OUT A MATRIX OF NROW BY NCOL ONTO DEVICE(IOUT).
C
C         A     = MATRIX
C         NROW  =NUMBER OF ROWS
C         NCOL  =NUMBER OF COLUMNS
C         NROWS =SUBMATRIX LOCATION IN ROW
C         NCOLS =SUBMATRIX LOCATION IN COLUMN
C
C         NOTE THAT NROW SHOULD BE LESS THAN 85.
C
        LARGE A(80,80)
        DATA ICOUNT/0/
        KEY=1
        ICOUNT=ICOUNT+1
        IF(ICOUNT.LE.4)KEY=2
        JS=1
        JSI=9
        IF(NCOL.LE.JSI) JSI=NCOL-1
        NHALF=NROW/2
        IF(NROW.LT.45) NHALF=NROW
        NPLUS=NHALF+1
        RM=FLOAT(NCOL)/10.0
        M=NCOL/10
        IF((RM-FLOAT(M)).GT.0.001) M=M+1
```

```
      DO 40 KK=1,M
      JT=JS JSI
      IF(KK.EQ.M) JT=NCOL
      WRITE(IOUT,100)
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)
      WRITE(IOUT,600) NROWS, NCOLS
C
C   BYPASS SUBROUTINE PRINTE TO AVOID EXCESSIVE PRINTOUT.
      IF(KEY.EQ.1)RETURN
      WRITE(IOUT,200) (J, J=JS,JT)
      DO 10 I=1,NHALF
   10 WRITE(IOUT,300) I,(A(I,J),  J=JS,JT)
      WRITE(IOUT,200) (J, J=JS,JT)
      IF(NPLUS.GT.NROW) GO TO 30
      WRITE(IOUT,100)
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)
      WRITE(IOUT,600) NROWS,NCOLS
      WRITE(IOUT,200) (J,J=JS,JT)
      DO 20 I=NPLUS,NROW
   20 WRITE(IOUT,300) I, (A(I,J), J=JS,JT)
      WRITE(IOUT,200) (J,J=JS,JT)
   30 JS=JT+1
   40 CONTINUE
C
  100 FORMAT(1H )
  200 FORMAT(/10I11 /)
  300 FORMAT(I5,10F11.5)
  400 FORMAT(///20X,33HDIRECT REQUIREMENT WITH HOUSEHOLD /)
  500 FORMAT(///20X,14HINVERSE MATRIX /)
  600 FORMAT(///25X,21HSUBMATRIX LOCATED AT(,I5,1H, ,I5, 1H) /)
C
      RETURN
      END


      SUBROUTINE PRINTF(K,L)
C   DUMMY ROUTINE TO SAVE PAPER
      WRITE(6,100)K,L
  100 FORMAT(1H0,2I5)
      RETURN
      END
```

FINAL

This program is to calculate the national final demands per $1000 contract cost for water resource investment by project type for the closed model in 1963 prices, the national final demands for the McClellan-Kerr Arkansas River Multiple purpose project contract cost and project cost, the regional final demands for the McClellan-Kerr Arkansas River Multiple purpose project contract cost and project cost, and the output for the 80 sector model.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA8C	12	input	Trade coefficients (4x4)
DATA9	14	input	Inverse matrix

Input Data Cards:

a) National final demands in 1958

b) Deflators

c) Ratio of contract cost to project cost

d) Contract cost and project cost

```
      PROGRAM FINAL(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE12,TA
C*****FINAL
C
C          TO COMPUTE FINAL DEMAND AND OUTPUT, GIVEN CONTRACT COST A
C          PROJECT CO T
C
C          12) INPUT FILE &GETC-DATA8
C          14) INPUT FILE &STEP2-DATA9
C
C
      DOUBLE PRECISION SUM, SUMY
      LARGE E(320,320)
      DIMENSION G( 0,80),C(4,4),T(4,4,80),Y(320),FY(81,5)
      DIMENSION XF(5,81), YF(5,81), XFC(5,81), YFC(5,81), XFR(5,81),
     1 YFR(5,81),X(320)
      COMMON/BK1/CCT(5),ALPHA(5),PC(5),B(81,4)  /BK2/INP,IOUT
      DATA NREG,NIND/4,79/
      INP=5
      IOUT=6
      NREGP=NREG+1
      NINDP=NIND+1
      NINDPP=NIND+2
      IMAXP=NREG*NINDP
C
C          READ INVERSE MATRIX
C
      DO 20 K=1,NREG
      DO 20 L=1,NREG
      READ(14) G
      DO 10 J=1,NINDP
      DO 10 I=1,NINDP
      KK=NINDP*(K-1)+I
      LL=NINDP*(L-1)+J
   10 E(KK,LL)=G(I,J)
      IF(K.GT.1)GO TO 20
      IF(L.EQ.1) CALL PRINTE(G,NINDP,NINDP,K,L,IOUT,2)
   20 CONTINUE
           READ  TRADE COEFFICIENTS

      DO 40 IND=1,NIND
      READ(12) C
      DO 30 L=1,NREG
      DO 30 K=1,NREG
   30 T(K,L,IND)=C(L,K)
   40 CONTINUE
           HOUSEHOLD SECTOR FOR TRADE COEFF

      DO 50 L=1,NREG
      DO 50 K=1,NREG
   50 T(K,L,NINDP)=0.0
      DO 60 K=1,NREG
   60 T(K,K,NINDP)=1.0

      DO 70 IREG=1,NREG
```

```
   70 WRITE(IOUT,201)(T(IREG,1,J),J=1,NINDP)
C
C         COMPUTE FINAL DEMAND
C
      CALL DEMAND
      KOST=1
   75 CALL CONTRC(KOST,FY)
C
C         COMPUTE OUTPUT
C
      JTYPE=5
      IMPACT=1
C
      DO 80 IREG=1,NREG
      DO 80 IND=1,NINDP
      JK=NINDP*(IREG-1)+IND
      Y(JK)=T(IREG,IMPACT,IND)*FY(IND,JTYPE)
   80 CONTINUE
C
      DO 100 I=1,IMAXP
      SUM=0.0
      DO 90 J=1,IMAXP
   90 SUM=SUM+E(I,J)*Y(J)
  100 X(I)=SUM
C
C         BREAK INTO REGIONAL GROUPS
C
      DO 110 IREG=1,NREG
      DO 110 IND=1,NINDP
      JK=NINDP*(IREG-1)+IND
      YF(IREG,IND)=Y(JK)
  110 XF(IREG,IND)=X(JK)
C
C         FIND ROW SUMS AND COLUMN SUMS
C
      DO 130 IND=1,NINDP
      SUM=0.0
      SUMY=0.0
      DO 120 IREG=1,NREG
      SUMY=SUMY+YF(IREG,IND)
  120 SUM=SUM+XF(IREG,IND)
      YF(NREG+1,IND)=SUMY
  130 XF(NREG+1,IND)=SUM
C
      DO 150 IREG=1,NREGP
      SUM=0.0
      SUMY=0.0
      DO 140 IND=1,NINDP
      SUMY=SUMY+YF(IREG,IND)
  140 SUM=SUM+XF(IREG,IND)
      YF(IREG,NINDP+1)=SUMY
      XF(IREG,NINDP+1)=SUM
  150 CONTINUE

          WRITE FINAL DEMAND AND OUTPUT
```

```
         PER  1000 DOLLARS

      CALL PRINTF(YF,NREGP, NINDPP, IOUT,1,1,KOST)
      CALL PRINTF(XF,NREGP, NINDPP, IOUT,1,2,KOST)

           IN PERCENTAGES BY COLUMN SUMS

      DO 160 IND=1,NINDPP
      DO 160 IREG=1,NREGP
C
C   CHECK FOR ZERO IN DENOMINATOR.
      IF(ABS(XF(IREG,NINDPP)).LT..00001)WRITE(6,1501)IREG
 1501 FORMAT(1X,6HTILT01,I5)
C   REPLACE ZEROS WITH ONES.
      IF(ABS(XF(IREG,NINDPP)).LT..00001)XF(IREG,NINDPP)=1.
C
      XFC(IREG,IND)=XF(IREG,IND)*100.0/XF(IREG,NINDPP)
C
C   CHECK FOR ZERO IN DENOMINATOR.
      IF(ABS(YF(IREG,NINDPP)).LT..00001)WRITE(6,1502)IREG
 1502 FORMAT(1X,6HTILT02,I5)
C   REPLACE ZEROS WITH ONES.
      IF(ABS(YF(IREG,NINDPP)).LT..00001)YF(IREG,NINDPP)=1.
C
      YFC(IREG,IND)=YF(IREG,IND)*100.0/YF(IREG,NINDPP)
  160 CONTINUE
      CALL PRINTF(YFC,NREG ,NINDPP,IOUT,2,1,KOST)
      CALL PRINTF(XFC,NREGP,NINDPP,IOUT,2,2,KOST)
C
C          IN PERCENTAGES BY ROW SUMS
C
      DO 170 IND=1,NINDPP
C
C   CHECK FOR ZERO IN DENOMINATOR.
      IF(ABS(XF(NREGP,IND)).LT..00001)WRITE(6,1503)IND
 1503 FORMAT(1X,6HTILT03,I5)
C   REPLACE ZEROS WITH ONES.
      IF(ABS(XF(NREGP,IND)).LT..00001)XF(NREGP,IND)=1.
C
      IF(ABS(YF(NREGP,IND)).LT..00001)WRITE(6,1504)IND
 1504 FORMAT(1X,6HTILT04,I5)
      IF(ABS(YF(NREGP,IND)).LT..00001)YF(NREGP,IND)=1.
C
      DO 170 IREG=1,NREGP
      XFR(IREG,IND)=XF(IREG,IND)*100.0/XF(NREGP,IND)
      YFR(IREG,IND)=YF(IREG,IND)*100.0/YF(NREGP,IND)
  170 CONTINUE
      CALL PRINTF(YFR,NREGP,NINDPP,IOUT,3,1,KOST)
      CALL PRINTF(XFR,NREGP,NINDPP,IOUT,3,2,KOST)

      KOST=KOST+1
      IF(KOST.LE.2) GO TO 75
  201 FORMAT(5G20.5)
      STOP
      END
```

```
      SUBROUTINE PRINTE(A,NROW,NCOL,NROWS,NCOLS,IOUT,ID)
C$$$$$SUBROUTINE PRINTE
C
C
C          TO PRINT OUT A MATRIX OF NROW BY NCOL ONTO DEVICE(IOUT).
C
C          A     = MATRIX
C          NROW  =NUMBER OF ROWS
C          NCOL  =NUMBER OF COLUMNS
C          NROWS =SUBMATRIX LOCATION IN ROW
C          NCOLS =SUBMATRIX LOCATION IN COLUMN
C
C          NOTE THAT NROW SHOULD BE LESS THAN 85.
C
      DIMENSION A(NROW,NCOL)
      JS=1
      JSI=9
      IF(NCOL.LE.JSI) JSI  COL-1
      NHALF=NROW/2
      IF(NROW.LT.45) NHALF=NROW
      NPLUS=NHALF+1
      RM=FLOAT(NCOL)/10.0
      M=NCOL/10
      IF((RM-FLOAT(M)).GT.0.001) M=M+1
C
      DO 40 KK=1,M
      JT=JS+JSI
      IF(KK.EQ.M) JT=NCOL
      WRITE(IOUT,100)
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)
      WRITE(IOUT,600) NROWS, NCOLS
      WRITE(IOUT,200) (J, J=JS,JT)
      DO 10 I=1,NHALF
   10 WRITE(IOUT,300) I,(A(I,J),  J=JS,JT)
      WRITE(IOUT,200) (J, J=JS,JT)
      IF(NPLUS.GT.NROW) GO TO 30
      WRITE(IOUT,100)
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)
      WRITE(IOUT,600) NROWS,NCOLS
      WRITE(IOUT,200) (J,J=JS,JT)
      DO 20 I=NPLUS,NROW
   20 WRITE(IOUT,300) I, (A(I,J), J=JS,JT)
      WRITE(IOUT,200) (J,J=JS,JT)
   30 JS=JT+1
   40 CONTINUE
C
  100 FORMAT(1H1)
  200 FORMAT(/10I11 /)
  300 FORMAT(I5,10F11.5)
  400 FORMAT(///20X,33HDIRECT REQUIREMENT WITH HOUSEHOLD /)
  500 FORMAT(///20X,14HINVERSE MATRIX /)
  600 FORMAT(///25X,21HSUBMATRIX LOCATED AT(,I5,1H, ,I5, 1H) /)

      RETURN

      END
```

```
      SUBROUTINE PRINTF(A,M,N,IOUT,IFCR,IXY,KOST)
C*****PRINTF
C
C
C
C        TO PRINT A MATRIX IN TRANSPOSED FORM
C
C            IFCR =1 &  PER 1000 DOLLARS
C                 =2 &  PERCENTAGES BY COLUMN SUMS
C                 =3 &  PERCENTAGES BY ROW SUMS
C
C            IXY  =1 &  FINAL DEMAND (= TY)
C                 =2 &  OUTPUT       (= X )
C
C            KOST =1 &  CONTRACT COST
C                 =2 &  PROJECT  COST
C
      DIMENSION A(M,N)
      IPAGE=1
      IS= 1
      IT=N/2
    5 IF(IXY.EQ.1) WRITE(IOUT,1000)
      IF(IXY.EQ.2) WRITE(IOUT,1500)
      IF(KOST.EQ.1)WRITE(IOUT,2001)
      IF(KOST.EQ.2) WRITE(IOUT,2002)
      IF(IFCR.EQ.1) WRITE(IOUT,3001)
      IF(IFCR.EQ.2) WRITE(IOUT,3002)
      IF(IFCR.EQ.3) WRITE(IOUT,3003)
      WRITE(IOUT,4000)
      DO 10  K=IS,IT
   10 WRITE(IOUT,100) K, (A(I,K), I=1,M)
      IF(IPAGE.EQ.2) GO TO 20
      WRITE(IOUT,5000)
      IS=IT+1
      IT=N-1
      IPAGE=2
      GO TO 5
   20 WRITE(IOUT,200) (A(I,N), I=1,M)
C
  100 FORMAT(I10,5F15.2)
  200 FORMAT(5X,5HTOTAL,5F15.2)
 1000 FORMAT(1H1,///8X,58HREGIONAL FINAL DEMAND FOR THE MCLELLAN-KE
     1KANSAS RIVER )
 1500 FORMAT(1H1,///8X,52H OUTPUT RESULTING FROM MCLELLAN-KERR ARKAN
     1 RIVER )
 2001 FORMAT(15X,38HMULTIPLE PURPOSE PROJECT CONTRACT COST )
 2002 FORMAT(15X,29HMULTIPLE PURPOSE PROJECT COST )
 3001 FORMAT(20X,23HPER $1000 - 1963 PRICES //)
 3002 FORMAT(20X,26HPERCENTAGES BY COLUMN SUMS //)
 3003 FORMAT(20X,23HPERCENTAGES BY ROW SUMS //)
 4000 FORMAT(3X,10HI-O SECTOR,  8X, 2HR1, 13X, 2HR2, 13X,2HR3,13X,2
     1 11X, 6HNATION //)
 5000 FORMAT(//40X,6H(OVER) )

      RETURN
      END
```



```
      SUBROUTINE DEMAND
C*****DEMAND
C
C
C
C          TO COMPUTE THE FINAL DEMAND VECTORS PER $1000 PROJECT COSTS
C          FOR A CLOSED INPUT-OUTPUT MODEL USING 1958 DATA WITH DEFLATORS
C
      DOUBLE PRECISION  SUM
      DIMENSION  IND(84), FX(84,12), FD(84,12), DEFL(84)
      COMMON  /BK1/ CCT(5), ALPHA(5), PC(5), B(81,4) /BK2/ INP,IOUT
      DATA NR,NC,NN/84,12,4/
      M=NR
      N=NC
      MN1=M-1
      NNP=NN+1
C
C          READ AND WRITE INPUT DATA
C
      WRITE(IOUT,100) (J, J=1,N)
      DO 10 I=1,M
      READ(INP,200) IND(I),(FX(I,J), J=1,N)
      DO 5  J=1,8
    5 FD(I,J)=FX(I,J)
      DO 6  J=9,11
    6 FD(I,J)=FX(I,J+1)
      FD(I,12)=FX(I,9)
      WRITE(IOUT,600) IND(I),(FD(I,J), J=1,N)
   10 CONTINUE
C
C          DEFLATOR
C
      WRITE(IOUT,300)
      DO 20 I=1,MN1
   20 READ(INP,400) IND(I), DEFL(I)
      WRITE(IOUT,450) (IND(I), DEFL(I), I=1,MN1)
C
C          CALULATE  NATIONAL FINAL DEMAND FOR 1963
      DO 25 I=1,MN1
      DO 25 J=1,N
      FD(I,J)=FD(I,J)*DEFL(I)/100.0
   25 CONTINUE
C
C          AGGREGATION TO MAKE HOUSEHOLD SECTOR
C
      M=81
      MN1=M-1
      DO 30 J=1,N
      TEMP=FD(80,J)+FD(81,J)+FD(82,J)+FD(83,J)
      FD(MN1,J)=TEMP
   30 CONTINUE
C
      DO 50 J=1,N
      SUM=0.0
      DO 40 I=1,MN1
   40 SUM=SUM+FD(I,J)
```

```
      FD(M,J)=SUM
   50 CONTINUE
      DO 60 J=1,N
      DO 60 I=1,M
C
C   CHECK FOR ZERO IN DENOMINATOR.
      IF(ABS(FD(M,J)).LT..00001) RITE(6,1500)M,J
 1500 FORMAT(1X,4HHELP,2I5)
C   REPLACE ZEROS WITH ONES.
      IF(ABS(FD(M,J)).LT..00001)FD(M,J)=1.0
C
   60 FD(I,J)=FD(I,J)*1000.0/FD(M,J)
C
C          WRITE AGGREGATED FINAL DEMAND
C
      WRITE(IOUT,500) (J,J=1,N)
      DO 70 I=1,40
   70 WRITE(IOUT,600) I,(FD(I,J), J=1,N)
      WRITE(IOUT,700)
      WRITE(IOUT,500) (J,J=1,N)
      DO 80 I=41,80
   80 WRITE(IOUT,600) I, (FD(I,J), J=1,N)
      WRITE(IOUT,800) (FD(M,J), J=1,N)
C
C          READ CONTRACT AND PROJECT COSTS
C
      READ(INP,900) (CCT(J), J=1,NNP)
      WRITE(IOUT,910)
      WRITE(IOUT,900)(CCT(J),J=1,NNP)
      READ(INP,1000)(ALPHA(J), J=1,NN)
      WRITE(IOUT,1000) (ALPHA(J),J=1,NN)
      READ(INP,900) (PC(J),J=1,NNP)
      WRITE(IOUT,920)
      WRITE(IOUT,900)(PC(J),J=1,NNP)
C
C          TAKE FOUR TYPES OF FINAL DEMANDS
C
      DO 90 I=1,M
      B(I,1)=FD(I,1)
      B(I,2)=FD(I,5)
      B(I,3)=FD(I,8)
      B(I,4)=FD(I,11)
   90 CONTINUE
C
  100 FORMAT(1H1,///8X,53HNATIONAL FINAL DEMAND PATTERN PER $1000 CONTRA
     1CT COST / 10X,45HFOR WATER RESOURCE INVESTMENT BY PROJECT TYPE,/
     2 15X,26HCLOSED MODEL - 1958 PRICES //3X,10HI-O SECTOR,12(I8,1X)//)
  200 FORMAT(I10,7F10.2/(5F10.2))
  300 FORMAT(1H1,///8X,9HDEFLATORS )
  400 FORMAT(I5,F15.2)
  450 FORMAT(5(I5,F15.2))
  500 FORMAT(1H1,///8X,53HNATIONAL FINAL DEMAND PATTERN PER $1000 CONTRA
     1CT COST,/10X,45HFOR WATER RESOURSE INVESTMENT BY PROJECT TYPE /
     2 15X,26HCLOSED MODEL - 1963 PRICES//3X,10HI-O SECTOR,12(I8,1X)//)
  600 FORMAT(I10,12F9.2)
  800 FORMAT(/40X, 6H(OVER) )
```

```
800 FORMAT(5X,5HTOTAL,12F9.2)
900 FORMAT(5F15.2)
910 FORMAT(1H1,///10X,13HCONTRACT COST )
920 FORMAT(///10X,12HPROJECT COST )
1000 FORMAT(4F10.5)
      RETURN
      END
```

```
      SUBROUTINE CONTRC(KOST,A)
C*****CONTRC
C
C
C           KOST= 1 &  CONTRACT COST
C           KOST= 2 &  PROJECT  COST
C
      DOUBLE PRECISION SUM
      DIMENSION A(81,5)
      COMMON /BK1/ CCT(5), ALPHA(5), PC(5), B(81,4) /BK2/ INP,IOUT
      DATA  NN,M/4,81/
      NNP=NN+1
      MN1=M-1
      IF(KOST.EQ.2) GO TO 68
C
C           CONTRACT COST
C
      ICOUNT=1
      DO 20 I=1,M
      DO 20 J=1,NN
      A(I,J)=B(I,J)*CCT(J)/1000.0
   20 CONTINUE
   25 DO 40 I=1,M
      SUM=0.0
      DO 30 J=1,NN
   30 SUM=SUM+A(I,J)
   40 A(I,NN+1)=SUM
C
      DO 55 J=1,NNP
      SUM=0.0
      DO 50 I=1,MN1
   50 SUM=SUM+A(I,J)
   55 A(M,J)=SUM
```

```
C
C        WRITE RESULTS
C
      IF(ICOUNT.EQ.1) WRITE(IOUT,200)
      IF(ICOUNT.EQ.2) WRITE(IOUT,250)
      WRITE(IOUT,300)
      DO 60 I=1,40
   60 WRITE(IOUT,400) I,(A(I,J), J=1,NNP)
      WRITE(IOUT,600)
C
      IF(ICOUNT.EQ.1) WRITE(IOUT,200)
      IF(ICOUNT.EQ.2) WRITE(IOUT,250)
      WRITE(IOUT,300)
      DO 65 I=41,80
   65 WRITE(IOUT,400) I,(A(I,J), J=1,NNP)
      WRITE(IOUT,500) (A(M,J),J=1,NNP)
      IF(ICOUNT.EQ.2) GO TO 999
      IF(KOST.EQ.1) GO TO 999
C        PROJECT COST
C
   68 ICOUNT=2
      DO 70 I=1,M
      DO 70 J=1,NN


      A(I,J)=B(I,J)*PC(J)*ALPHA(J)/1000.0
      IF(I.EQ.MN1) A(I,J)=A(I,J)+PC(J)*(1.0-ALPHA(J))
   70 CONTINUE
      GO TO 25
C
  200 FORMAT(1H1,///8X,58HNATIONAL FINAL DEMAND FOR THE MCLELLAN-KERR A
     1KANSAS RIVER  / 15X,38HMULTIPLE PURPOSE PROJECT CONTRACT COST /
     2 20X,23HPER $1000 - 1963 PRICES ///)
  250 FORMAT(1H1,///8X,58HNATIONAL FINAL DEMAND FOR THE MCLELLAN-KERR A
     1KANSAS RIVER /15X,29HMULTIPLE PURPOSE PROJECT COST  /20X,23HPER $
     2000 - 1963 PRICES ///)
  300 FORMAT(20X, 8HMULTIPLE,5X, 5HFLOOD, 8X,10HREVETMENTS,3X,11HLOCK &
     1DAMS,3X,5HTOTAL / 21X,7HPURPOSE,6X, 7HCONTROL,33X,7HPROJECT  /
     2 3X, 10HI-O SECTOR /)
  400 FORMAT(I8,7X,5F13.2)
  500 FORMAT(5X,5HTOTAL,5X,5F13.2)
  600 FORMAT(/40X,6H(OVER) )
  999 RETURN
      END
```

FEEP

The submatrices of the inverse matrix $(I-TA)^{-1}$ is printed out with the page numbers by this program.

Data Files

Data Set Name	Logical Unit	Type	Description
DATA9	14	input	Inverse matrix

Input Data Cards:

No card is needed.

```
      PROGRAM FEEP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE14)
      DIMENSION G(80,80)
      DATA NREG,NINDP/4,80/
      IOUT=6
      IPAGE=1
      DO 10 I=1,NREG
      DO 10 J=1,NREG
      READ(14)G
      WRITE(6,100)I,J
  100 FORMAT(1X,2I5)
      IF(I.NE.J)GO TO 10
      CALL PRINTG(G,NINDP,NINDP,I,J,IOUT,2,IPAGE)
   10 CONTINUE
C
      STOP 0000
      END

      SUBROUTINE PRINTG(A,NROW,NCOL,NROWS,NCOLS,IOUT,ID,IPAGE)
C*********SUBROUTINE PRINTG
C
C
C           TO PRINT OUT A MATRIX OF NROW BY NCOL ONTO DEVICE(IOUT).
C
C           A     = MATRIX
C           NROW  =NUMBER OF ROWS
C           NCOL  =NUMBER OF COLUMNS
C           NROWS =SUBMATRIX LOCATION IN ROW
C           NCOLS =SUBMATRIX LOCATION IN COLUMN
C
C           NOTE THAT NROW SHOULD BE LESS THAN 85.
C
      DIMENSION A(NROW,NCOL)
      JS=1
      JSI=9
      IF(NCOL.LE.JSI) JSI=NCOL-1
      NHALF=NROW/2
      IF(NROW.LT.45) NHALF=NROW
      NPLUS=NHALF+1
      RM=FLOAT(NCOL)/10.0
      M=NCOL/10
      IF((RM-FLOAT(M)).GT.0.001) M=M+1
C
      DO 40 KK=1,M
      JT=JS+JSI
      IF(KK.EQ.M) JT=NCOL
      WRITE(IOUT,100)
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)IPAGE
      WRITE(IOUT,600) NROWS, NCOLS
      WRITE(IOUT,200) (J, J=JS,JT)
      DO 10 I=1,NHALF
   10 WRITE(IOUT,300) I,(A(I,J),  J=JS,JT)
      WRITE(IOUT,200) (J, J=JS,JT)
      IF(NPLUS.GT.NROW) GO TO 30
      WRITE(IOUT,100)
```

```
      IPAGE=IPAGE+1
      IF(ID.EQ.1) WRITE(IOUT,400)
      IF(ID.EQ.2) WRITE(IOUT,500)IPAGE
      WRITE(IOUT,600) NROWS,NCOLS
      WRITE(IOUT,200) (J,J=JS,JT)
      DO 20 I=NPLUS,NROW
   20 WRITE(IOUT,300) I, (A(I,J), J=JS,JT)
      WRITE(IOUT,200) (J,J=JS,JT)
   30 JS=JT+1
      IPAGE=IPAGE+1
   40 CONTINUE
C
  100 FORMAT(1H1)
  200 FORMAT(/10I11 /)
  300 FORMAT(I5,10F11.5)
  400 FORMAT(///20X,≠DIRECT REQUIREMENT WITH HOUSEHOLD ≠/)
  500 FORMAT(///20X,≠INVERSE MATRIX≠50X,≠PAGE≠,I5 /)

  600 FORMAT(25X,≠SUBMATRIX LOCATED AT(≠,I5,≠,≠,I5,≠)≠/)
C
      RETURN
      END
```

B. 10 Sector Model

AGGREG

This program performs the aggregation of the industrial sectors from 84x84 into an 11x11 matrix using a regional input-output table. Punched cards can be obtained as output.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA4	8	input	Regional I/O tables (84x84)

Input Data Cards:

Control Card:

M(K): The row or the column number where the aggregation starts. Aggregation continues up to the row or the column before the next M.

In our case,

M(K) = 1,5,11,13,35,65,69,70,72,78,80,81,82,83,84

```
@FOR,IS AGGREG,A GREG
C*****AGGREG
C
C       TO AGGREGATE FOUR REGIONAL TABLES  FROM 84X84 INTO 11X11 MAT
C
C       8) INPUT FILE = DATA4    OUTPUT OF REGIO
C
        DIMENSION A(84,84),M(15),T(15,15),IB(20)
        DOUBLE PRECISION SUM


        DATA INPUT,IOUT/5,6/,ISECT/14/
        DATA KMAX,IREG,LAB,IROW,ICOL/15,4,20,84,84/
C
C           READ AND WRITE MATRIX OPERATION GUIDE
C
        READ(INPUT,300) (M(K),K=1,KMAX)
        WRITE(IOUT,300) (M(K),K=1,KMAX)
C
        CALL NTRAN(8,10,22)
        DO 95 KKK=1,IREG
        CALL NTRAN(8,2,LAB,IB,LAY,22)
        WRITE(IOUT,700) (IB(J),J=1,LAB)
        CALL NTRAN(8,2,IROW*ICOL,A,LAY,22)
        WRITE(IOUT,800) (A(1,J),J=1,ICOL)
C
C       AGGREGATION
C
        DO 80 K=1,ISECT
        DO 80 L=1,ISECT
        IPL=M(K+1)-1
        IRL=M(L+1)-1
        IPS=M(K)
        IRS=M(L)
        SUM=0.0
        DO 70 I=IPS,IPL
        DO 70 J=IRS,IRL
        SUM=SUM+A(I,J)
     70 CONTINUE
        T(K,L)=SUM
     80 CONTINUE
C
C       COMPUTE SUMMATION
C
        DO 86 I=1,ISECT
        SUM=0.0
        DO 85 J=1,ISECT
     85 SUM=SUM+T(I,J)
        T(I,ISECT+1)=SUM
     86 CONTINUE
        ISECTP=ISECT+1
        DO 88 J=1,ISECTP
        SUM=0.0
        DO 87 I=1,ISECT
     87 SUM=SUM+T(I,J)
        T(ISECTP,J)=SUM
     88 CONTINUE
        WRITE(IOUT,900)
```

```
      DO 90 K=1,ISECTP
      WRITE(1,409)K,(T(K,L),L=1,ISECTP)
   90 WRITE(IOUT,400) K  (T(K,L),L=1,ISECTP)
   95 CONTINUE
C
C
  500 FORMAT(1515)
  400 FORMAT(5X,I5,5F20.2/(6F20.2))
  409 FORMAT(5X,I5,3F20.2/(4F20.2))
  700 FORMAT(1H1,20A6)
  800 FORMAT(8E15.4)
  900 FORMAT(///T10,'REDUCED MATRIX FOR REGIONAL I-O MODEL WITH 10 SE.
     1RS'//)
      STOP

      END
```

TRAAGG

The trade flows of the 80 sector model are aggregated into the ones of the 10 sector model by this program.

Punched cards can be obtained as output.

Data Files:

Data Set Name	Logical Unit	Type	Description
DATA7	8	input	Regional trade flows (5x5)

Input Data Cards:

Control Card:

NSTATE: The identification number of the industry sector.

If NSTATE=999, the execution is terminated.

If NSTATE=1000, the aggregating operation is interrupted to make a new industrial sector and continues the operation for the next industrial sector.

```
@FOR,IS TRAAGG.TRAAGG
C****TRAAGG
C
C     TO MAKE AGGREG'TION OF TRADE FLOW INTO  10 INDUSTRIES.
C
C     8) INPUT FILE = DATA7   OUTPUT OF TRADE
C
      DOUBLE PRECISION DY(5,5),DYS(5,5)
      DIMENSION IB(20),Y(5,5)
      DATA NR,NC,LAB/5,5,20/
C
C
C
C                                                  INITIALIZATION
    1 DO 10 I=1,NR
      DO 10 J=1,NC
   10 DYS(I,J)=0.0
C
C                                                  READ INPUT FILES
C
C     NSTATE IS INDUSTRY NUMBER
   15 READ(5,100)NSTATE
      IF(NSTATE.EQ.999)STOP
      IF(NSTATE.EQ.1000) GO TO 45
      CALL NTRAN(8,10,22)
      DO 20  KK=1,NSTATE
      CALL NTRAN(8,2,LAB,IB,LAY,22)
      CALL NTRAN(8,2,NR*NC,Y,LAY,22)
   20 CONTINUE
C
C                                                  WRITE  INPUT FILE
      WRITE(6,300)NSTATE
      WRITE(6,400)(IB(J),J=1,20)
      WRITE(6,500)(J,Y(1,J),J=1,NC)
C
C                                          AGGREGATION
C
      DO 30 I=1,NR
      DO 30 J=1,NC
   30 DY(I,J)=Y(I,J)
      DO 40 I=1,NR
      DO 40 J=1,NC
   40 DYS(I,J)=DYS(I,J)+DY(I,J)
      GO TO 15
C
   45 DO 50 I=1,NR
      DO 50 J=1,NC
   50 Y(I,J)=DYS(I,J)
C
C                                                  WRITE  OUTPUT FILE
C
      WRITE(6,600)
      DO 60 K=1,NR
      WRITE(1,450) (Y(K,L),L=1,NC)
   60 WRITE(6,450)(Y(K,L),L=1,NC)
  100 FORMAT(I5)
  150 FORMAT(12A6)
  300 FORMAT(5X,'INDUSTRY =',I5//)
  400 FORMAT(20A6)
  450 FORMAT(4F20.2)
  500 FORMAT(8(I5,E10.4))
```

```
600 FORMAT(1H1,5X,'TRADE FLOW'///)
    GO TO 1
    END
```

SENFIN

This is a program to calculate the national final demands, the regional final demands, the multipliers, and output for the 10 sector model using the 10 sector regional input-output tables and the 10 sector regional trade flow tables. In order to invert the matrix, I-TA, the subroutine INVERT from BMD03R is used. For a given project type and a given impact region, the regional final demands and the resulting outputs can be computed. Since this program does not require a large memory, the sensitivity analysis can be performed.

Data Files:

No tape is used.

Input Data Cards:

a) 10 sector regional input-output tables

b) 10 sector trade flow tables

c) Household sector coefficients

d) National final demands

e) Deflators

f) Project and contract cost

g) Ratio of contract to project cost

h) Title cards

i) Control cards for the dynamic output format control FM1 and FM2

j) Control card for aggregation of the final demands.

In our case,

L(K)=1,5,11,13,35,65,69,70,72,78,80,84,85

Print-outs

Group 1

a) Regional I/O table for each region (15x15)

b) Trade flows for each industry (5x5)

c) Trade coefficient for each industry (4x4)

d) Technical coefficients (A_N) (40x40)

e) Technical coefficients with household sector (A_H) (44x44)

f) Trade coefficients (T_N) (40x40)

g) Trade coefficients with household sector (T_H) (44x44)

h) Direct requirements ($T_N A_N$) (40x40)

i) Direct requirements with household sector ($T_H A_H$) (44x44)

j) Direct plus indirect requirements $[(I-T_N A_N)^{-1}]$ (40x40)

k) Direct plus indirect plus induced requirements $[(I-T_H A_H)^{-1}]$ (44x44)

l) Direct income change (10x4)

m) Direct and indirect income change (10x4)

n) Indirect income change (10x4)

o) Income multiplier type 1 (10x4)

p) Direct plus indirect plus induced income change (10x4)

q) Induced income change (10x4)

r) Indirect and induced income change (10x4)

s) Income multiplier type 2 (10x4)

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t) Output multiplier type 1 (10x4)

u) Output multiplier type 2 (10x4)

v) Sum of output multiplier type 1 (1x4)

w) Sum of output multiplier type 2 (1x4)

Group 2

a) National final demand vectors in 1958 (84x12)

b) Deflators

c) National final demand vectors in 1963 (12x12)

d) Contract cost (1x5)

e) Project cost (1x5)

f) National final demand vectors for the McClellan-Kerr Arkansas River multiple purpose project contract cost per $1000 in 1963 prices (12x5)

g) Regional final demands for each impact region and for each type of project (12x5)

h) Output for each impact region and for each type of project (12x5)

```
//*  SENFIN   COMPLETE
//STEP1 EXEC FORTRANH
//SOURCE.SYSIN DD *
C********SENFIN
C
C           INTER-REGIONAL INPUT-OUTPUT ANALYSIS
C             FOUR REGIONS WITH 10 SECTORS
C
      DIMENSION JB(20),A(15,15),ACOEFF(4,10,10),BCOEFF(4,11,11),CCOEFF(
     1,4,11),AHAT(10,10),T(5,5)
      DIMENSION AN(40,40),AH(44,44),TN(40,40),TH(44,44)
      DIMENSION B(40,40),C(44,44),D(40,40),E(44,44)
      DIMENSION LK(40),MK(40),LKP(44),MKP(44)
      DIMENSION FMT1(18),FMT2(18)
      COMMON /BK1/FD(84,12),DEFL(84),M,N,IOUT,INP
      COMMON /BK2/FA(12,12)
      COMMON /BK3/ CCOEFF, D, E
      DATA NREG,NIND/4,10/
      DATA NR,NC,LAB/15,15,20/
C
      INP=5
      IOUT=6
      NREGP=NREG+1
      NINDP=NIND+1
      IMAX=NREG*NIND
      IMAXP=NREG*NINDP
C
C          READ FORMAT STATEMENT FOR OUTPUTS OF PRINTA
C
1     FORMAT(18A4)
      READ(INP,1) FMT1
C--------             FMT1:(I5,10F11.0)
      READ(INP,1) FMT2
C--------             FMT2:(I5,10F11.5)
C
      DO 110 IREG=1,NREG
C
C          READ AND WRITE REGINAL I-O TABLES
C
      READ(INP,101)(JB(J),J=1,LAB)
      DO 10 K=1,NR
   10 READ(INP,201) KK,(A(K,L),L=1,NC)
      CALL PRINTA(A,NR,NC,JB,LAB,IOUT,FMT1)
      DO 60 J=1,NIND
```

```
      DO 60 I=1,NIND
   60 AHAT(I,J)=A(I,J)/A(NR,J)
      DO 80 I=1,NIND
      DO 80 J=1,NIND
   80 ACOEFF(IREG,I,J)=AHAT(I,J)
  110 CONTINUE
C
      DO 85 L=1,IMAX
      DO 85 M=1,IMAX
   85 AN(L,M)=0.0
      DO 90 K=1,NREG
      DO 90 I=1,NIND
      DO 90 J=1,NIND
      L=NIND*(K-1)+I
      M=NIND*(K-1)+J
      AN(L,M)=ACOEFF(K,I,J)
   90 CONTINUE
C
C          HOUSEHOLD SECTOR IS CONSIDERED - TECH COEFF
C
      DO 130 IREG=1,NREG
      READ(INP,401)(BCOEFF(IREG,I,NINDP), I=1,NINDP)
      READ(INP,401)(BCOEFF(IREG,NINDP,J), J=1,NINDP)
      DO 120 I=1,NIND
      DO 120 J=1,NIND
  120 BCOEFF(IREG,I,J)=ACOEFF(IREG,I,J)
  130 CONTINUE
      DO 140 L=1,IMAXP
      DO 140 M=1,IMAXP
  140 AH(L,M)=0.0
      DO 150 K=1,NREG
      DO 150 I=1,NINDP
      DO 150 J=1,NINDP
      L=NINDP*(K-1)+I
      M=NINDP*(K-1)+J
      AH(L,M)=BCOEFF(K,I,J)
  150 CONTINUE
C
C          TRADE COEFF
C
      READ(INP,101)(JB(J),J=1,LAB)
      WRITE(IOUT,101)(JB(J),J=1,LAB)
      DO 360 IND=1,NIND
      WRITE(IOUT,301) IND
      DO 160 I=1,NREGP
```

```
      READ(INP,501)(T(I,J),J=1,NREGP)
  160 WRITE(IOUT,501)(T(I,J), J=1,NREGP)
      DO 170 I=1,NREG
      DO 170 J=1,NREG
  170 CCOEFF(I,J,IND)=T(I,J)/T(NREGP,J)
  360 CONTINUE
C
      DO 180 L=1,IMAX
      DO 180 M=1,IMAX
  180 TN(L,M)=0.0
      DO 190 I=1,NREG
      DO 190 J=1,NREG
      DO 190 K=1,NIND
      L=NIND*(I-1)+K
      M=NIND*(J-1)+K
  190 TN(L,M)=CCOEFF(I,J,K)
C
C          HOUSEHOLD SECTORS - TRADE COEFF
      DO 210 I=1,NREG
      DO 210 J=1,NREG
210   CCOEFF(I,J,NINDP)=0.0
      DO 215 K=1,NREG
215   CCOEFF(K,K,NINDP)=1.0
      DO 220 L=1,IMAXP
      DO 220 M=1,IMAXP
  220 TH(L,M)=0.0
      DO 230 I=1 NREG
      DO 230 J=1,NREG
      DO 230 K=1,NINDP
      L=NINDP*(I-1)+K
      M=NINDP*(J-1)+K
  230 TH(L,M)=CCOEFF(I,J,K)
      DO 240 K=1,NINDP
      WRITE(IOUT,801) K
      DO 235 I=1,NREG
  235 WRITE(IOUT,901)(CCOEFF(I,J,K),J=1,NREG)
  240 CONTINUE
C
101   FORMAT(20A4)
201   FORMAT(I10,3F20.2/(4F20.2))
301   FORMAT(//T10,'TRADE FLOW FOR INDUSTRY',I5,//)
401   FORMAT(8F10.6)
501   FORMAT(4F20.2)
  801 FORMAT(///T10,'TRADE COEFFICIENT FOR INDUSTRY',I5,///)
  901 FORMAT(1H0,4F20.5)
```

```
C
C         COMPUTE T*A AND TH*AH
C
      CALL MULTI(TN,AN,B,IMAX,IMAX,IMAX)
      CALL MULTI(TH,AH,C,IMAXP,IMAXP,IMAXP)
C
C         COMPUTE INVERSE OF (I-TA) AND (I-TH*AH)
C
      CALL REQUIR(B,D,IMAX,LK,MK)
      CALL REQUIR(C,E,IMAXP,LKP,MKP)
C
C
C         WRITE COMPUTE VALUES
C
C        TECHNICAL COEFFICIENTS
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(AN,IMAX,IMAX,JB,LAB,IOUT,FMT2)
C        TECH COEFF WITH HOUSEHOLD
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(AH,IMAXP,IMAXP,JB,LAB,IOUT,FMT2)
C        TRADE COEFF
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(TN,IMAX,IMAX,JB,LAB,IOUT,FMT2)
C        TRADE COEFF WITH HOUSEHOLD
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(TH,IMAXP,IMAXP,JB,LAB,IOUT,FMT2)
C        DIRECT REQUIREMENTS
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(B,IMAX,IMAX,JB,LAB,IOUT,FMT2)
C        DIRECT REQUIREMENTS WITH HOUSHOLD
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(C,IMAXP,IMAXP,JB,LAB,IOUT,FMT2)
C         DIRECT PLUS INDIRECT REQUIREMENTS
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(D,IMAX,IMAX,JB,LAB,IOUT,FMT2)
C         DIRECT PLUS INDIRECT PLUS INDUCED REQUIREMENTS
      READ(INP,101)(JB(J),J=1,LAB)
      CALL PRINTA(E,IMAXP,IMAXP,JB,LAB,IOUT,FMT2)
C
C         TO COMPUTE  INCOME CHANGES AND MULTIPLIERS
C
      DOUBLE PRECISION SUM
      DIMENSION G(4,10),F(4,10),GF(4,10),H(4,10)
      DIMENSION O(4,10),OF(4,10),OG(4,10),S(4,10)
      DIMENSION P(4,10),R(4,10),U(4),V(4)
```

```
      DIMENSION PS(40), RS(44),FF(4,4,10)
C
      DO 12 I=1,NREG
      DO 12 J=1,NREG
      DO 12 K=1,NIND
      JK=NINDP*(J-1)+K
      IF(I.NE.J) GO TO 12
      G(I,K)=C(NINDP*I,JK)
   12 CONTINUE
C
      DO 42 J=1,NREG
      DO 42 K=1,NIND
      DO 42 I=1,NREG
      SUM=0.0
      DO 22 L=1,NIND
      KK=NIND*(J-1)+K
      LL=NIND*(I-1)+L
22    SUM=SUM+G(I,L)*D(LL,KK)
      FF(I,J,K)=SUM
   42 CONTINUE
      DO 54 J=1,NREG
      DO 54 K=1,NIND
      SUM=0.0
      DO 44 I=1,NREG
   44 SUM=SUM+FF(I,J,K)
   54 F(J,K)=SUM
C
      DO 51 I=1,NREG
      DO 51 K=1,NIND
      SUM=0.0
      IK=NINDP*(I-1)+K
      DO 50 J=1,NREG
50    SUM=SUM+E(NINDP*J,IK)
51    Q(I,K)=SUM
      DO 52 I=1,NREG
      DO 52 K=1,NIND
      GF(I,K)=F(I,K)-G(I,K)
      H(I,K)=F(I,K)/G(I,K)
      QF(I,K)=Q(I,K)-F(I,K)
      QG(I,K)=Q(I,K)-G(I,K)
      S(I,K)=Q(I,K)/G(I,K)
   52 CONTINUE
      DO 72 KK=1,IMAX
      SUM=0.0
      DO 82 LL=1,IMAX
```

```
   82 SUM=SUM+D(LL,KK)
   72 PS(KK)=SUM
      DO 73 J=1,NREG
      DO 73 K=1,NIND
      KK=K+NIND*(J-1)
   73 P(J,K)=PS(KK)
      DO 95 KK=1,IMAXP
      SUM=0.0
      DO 92 LL=1,IMAXP
   92 SUM=SUM+E(LL,KK)
   95 RS(KK)=SUM
      DO 93 J=1,NREG
      DO 93 K=1,NINDP
      KK=K+NINDP*(J-1)
   93 R(J,K)=RS(KK)
C
      DO 102 I=1,NREG
      SUM=0.0
      DO 112 K=1,NIND
  112 SUM=SUM+H(I,K)
  102 U(I)=SUM
C
      DO 122 I=1,NREG
      SUM=0.0
      DO 132 K=1,NIND
  132 SUM=SUM+S(I,K)
  122 V(I)=SUM
C
      WRITE(IOUT,900)
  900 FORMAT(1H1,///T10,'DIRECT INCOME CHANGE'///)
      CALL PRINTB(G,NREG,NIND,IOUT,1)
      WRITE(IOUT,1000)
1000  FORMAT(1H1,///T10,'DIRECT AND INDIRECT INCOME CHANGE'///)
      CALL PRINTB(F,NREG,NIND,IOUT,1)
      WRITE(IOUT,1100)
1100  FORMAT(1H1,///T10,'INDIRECT INCOME CHANGE'///)
      CALL PRINTB(GF,NREG,NIND,IOUT,1)
      WRITE(IOUT,1200)
1200  FORMAT(1H1,///T10,'INCOME MULTIPLIER TYPE 1',///)
      CALL PRINTB(H,NREG,NIND,IOUT,1)
      WRITE(IOUT,1300)
1300  FORMAT(1H1,///T10,'DIRECT PLUS INDIRECT PLUS INDUCED INCOME CHANG
     <'///)
      CALL PRINTB(O,NREG,NIND,IOUT,1)
      WRITE(IOUT,1400)
```

```
1400  FORMAT(1H1,///T10,'INDUCED INCOME CHANGE'///)
      CALL PRINTB(QF,NREG,NIND,IOUT,1)
      WRITE(IOUT,1500)
1500  FORMAT(1H1,///T10,'INDIRECT AND INDUCED INCOME CHANGE'///)
      CALL PRINTB(QG,NREG,NIND,IOUT,1)
      WRITE(IOUT,1600)
1600  FORMAT(1H1,///T10,'INCOME MULTIPLIER TYPE 2'///)
      CALL PRINTB(S,NREG,NIND,IOUT,1)
      WRITE(IOUT,1700)
1700  FORMAT(1H1,///T10,' OUTPUT MULTIPLIER TYPE 1 '///)
      CALL PRINTB(P,NREG,NIND,IOUT,1)
      WRITE(IOUT,1800)
1800  FORMAT(1H1,///T10,'OUTPUT MULTIPLIER TYPE 2'///)
      CALL PRINTB(R,NREG,NIND,IOUT,1)
      WRITE(IOUT,1900)
1900  FORMAT(1H1,///T10,'SUM OF OUTPUT MULTIPLIER TYPE 1'///)
      CALL PRINTC(U,NREG,IOUT)
      WRITE(IOUT,2000)
2000  FORMAT(1H1,///T10,'SUM OF OUTPUT MULTIPLIER TYPE 2'///)
      CALL PRINTC(V,NREG,IOUT)
C
C        CALL A SUBPROGRAM FOR FINAL DEMAND
C
      CALL FINALE
      STOP
      END
C*****MULTI
      SUBROUTINE MULTI(A,B,C,M,L,N)
C
C         TO MULTIPLY TWO MATRICES
C
C         C(I,J)=A(I,K)*B(K,J)
C
      DOUBLE PRECISION SUM
      DIMENSION C(M,N),A(M,L),B(L,N)
      DO 10 I=1,M
      DO 10 J=1,N
   10 C(I,J)=0.0
      DO 30 I=1,M
      DO 30 J=1,N
      SUM=0.0
      DO 20 K=1,L
   20 SUM=SUM+A(I,K)*B(K,J)
      C(I,J)=SUM
   30 CONTINUE
```

```
      RETURN
      END
C*****REQUIR
      SUBROUTINE REQUIR(A,BX,M,LK,MK)
C
C          TO COMPUTE INVERSE OF (I-A)
      DIMENSION A(M,M),BX(M,M),LK(M),MK(M)
      DO 10 I=1,M
      DO 10 J=1,M
      BX(I,J)=-A(I,J)
      IF(I.EQ.J) BX(I,J)=1.0-A(I,J)
   10 CONTINUE
      CALL INVERT(BX,M,LK,MK)
      RETURN
      END
C*****INVERT
      SUBROUTINE INVERT (A,N,L,M)
C     PROGRAM FOR FINDING THE INVERSE OF A NXN MATRIX
      DIMENSION A(N,N),L(N),M(N)
C     SEARCH FOR LARGEST ELEMENT
C
      D=1.
      DO80 K=1,N
      L(K)=K
      M(K)=K
      BIGA=A(K,K)
      DO 20 I=K,N
      DO 20 J=K,N
      IF(ABS(BIGA)-ABS(A(I,J))) 10,20,20
   10 BIGA=A(I,J)
      L(K)=I
      M(K)=J
   20 CONTINUE
C     INTERCHANGE ROWS
      J=L(K)
      IF(L(K)-K) 35,35,25
25    DO 30 I=1,N
      HOLD=-A(K,I)
      A(K,I)=A(J,I)
30    A(J,I)=HOLD
C     INTERCHANGE COLUNMS
   35 I=M(K)
      IF(M(K)-K) 45,45,37
37    DO 40 J=1,N
      HOLD=-A(J,K)
```

```
      A(J,K)=A(J,I)
   40 A(J,I)=HOLD
C     DIVIDE COLUMNS BY MINUS PIVOT
45    DO 55 I=1,N
   46 IF(I-K)50,55,50
   50 A(I,K)=A(I,K)/(-A(K,K))
   55 CONTINUE
C     REDUCE MATRIX
      DO 65 I=1,N
      DO 65 J=1,N
   56 IF(I-K) 57,65,57
   57 IF(J-K) 60,65,60
   60 A(I,J)=A(I,K)*A(K,J)+A(I,J)
   65 CONTINUE
C     DIVIDE ROW BY PIVOT
      DO 75 J=1,N
   68 IF(J-K)70,75,70
   70 A(K,J)=A(K,J)/A(K,K)
   75 CONTINUE
C     CONTINUED PRODUCT OF PIVOTS
      D=D*A(K,K)
C     REPLACE PIVOT BY RECIPROCAL
      A(K,K)=1.0/A(K,K)
   80 CONTINUE
C     FINAL ROW AND COLUMN INTERCHANGE
      K=N
  100 K=(K-1)
      IF(K) 150,150,103
  103 I=L(K)
      IF(I-K) 120,120,105
105   DO 110 J=1,N
      HOLD=A(J,K)
      A(J,K)=-A(J,I)
  110 A(J,I)=HOLD
  120 J=M(K)
      IF(J-K) 100,100,125
125   DO 130 I=1,N
      HOLD=A(K,I)
      A(K,I)=-A(J,I)
  130 A(J,I)=HOLD
      GO TO 100
  150 RETURN
      END
C*****PRINTA
C
```

```
C
      SUBROUTINE PRINTA(A,NROW,NCOL,JB,LAB,IOUT,FMT)
C
C          TO PRINT OUT A MATRIX OF NROW BY NCOL ONTO DEVICE(IOUT).
C          ALPHANUMERIC STRING CAN BE PRINTED IF GIVEN.
C
C                A =  MATRIX
C                NROW=NUMBER OF ROW
C                NCOL=NUMBER OF COLUMN
C                JB=  ALPHANUMERIC STRING,(A4 FORMAT)
C                LAB= NUMBER OF JB   (TO SKIP, LAB=0)
C                IOUT= OUTPUT DEVICE
C
C          NOTE THAT NROW SHOULD BE LESS THAN 85.
C
      DIMENSION A(NROW,NCOL), JB(LAB),FMT(18)
      JS=1
      JSI=9
      IF(NCOL .LE. JSI) JSI=NCOL-1
      NHALF=NROW/2
      IF(NROW .LT. 45)  NHALF=NROW
      NPLUS=NHALF+1
      RM=FLOAT(NCOL)/10.0
      M= NCOL /10
      IF((RM-FLOAT(M)).GT. 0.001)  M=M+1
C
      DO 40 KK=1,M
      JT=JS+JSI
      IF(KK .EQ. M) JT=NCOL
      IF(LAB .NE.0) WRITE(IOUT,100) (JB(J),J=1,LAB)
      WRITE(IOUT,200) (J, J=JS,JT)
      DO 10 I=1,NHALF
   10 WRITE(IOUT,FMT) I, (A(I,J), J=JS,JT)
      WRITE(IOUT,200) (J, J=JS,JT)
      IF(NPLUS .GT. NROW)  GO TO 30
C
      IF(LAB .NE. 0) WRITE(IOUT,100) (JB(J),J=1,LAB)
      WRITE(IOUT,200) (J,J=JS,JT)
      DO 20 I=NPLUS,NROW
   20 WRITE(IOUT,FMT) I, (A(I,J), J=JS,JT)
      WRITE(IOUT,200) (J,J=JS,JT)
   30 JS=JT+1
   40 CONTINUE
C
100   FORMAT(1H1,///20A4,///)
```

```
  200 FORMAT(/ 10I11 /)
      RETURN
      END
C*****PRINTB
          SUBROUTINE PRINTB(A,M,L,IOUT,INX)
      DIMENSION A(M,L)
C
C         PRINT OUTPUTS IN TRANSPOSED FORM
C
      DO 10 K=1,L
      IF(INX.EQ.1) WRITE(IOUT.100) (A(I,K),I=1,M)
      IF(INX.EQ.2) WRITE(IOUT.200) K, (A(I,K),I=1,M)
10    CONTINUE
  100 FORMAT(4F20.5)
200   FORMAT(I10,5F15.2)
      RETURN
      END
C*****PRINTC
          SUBROUTINE PRINTC(A,M,IOUT)
      DIMENSION A(M)
C
C         PRINT OUTPUTS IN TRANSPOSED FORM
C
      WRITE(IOUT,100)(A(I),I=1,M)
  100 FORMAT(4F20.5)
      RETURN
      END
C*****FINALE
C
      SUBROUTINE FINALE
C
C                        FINAL DEMAND FOR PROJECT COST
C
      DIMENSION X(44), Y(44), XF(5,12), YF(5,12),FY(12,5)
      DIMENSION CCOEFF(4,4,11), D(40,40), E(44,44)
      COMMON /BK1/FD(84,12),DEFL(84),M,N,IOUT,INP
      COMMON /BK2/FA(12,12)
      COMMON /BK3/ CCOEFF, D, E
      LOGICAL HOUSE
      DATA KOST/1/, HOUSE/.TRUE./
      DATA NREG,NIND/4,10/
C
C         KOST=0        NO COMPUTATION  FOR CONTRACT COST OR PROJECT COST
C         KOST=1        CONTRACT COST ONLY
C         KOST=2        PROJECT COST ONLY
```

```
C     KOST=3       BOTH COST ARE USED BUT RETURNED VALUES ARE

      NREGP=NREG+1
      NINDP=NIND+1
      IMAX=NREG*NIND
      IMAXP=NREG*NINDP

C        COMPUTE FINAL DEMAND

      CALL DEMAND(KOST,FY)

C        COMPUTE OUTPUT

      NTYPE=12
      IF(KOST.NE.0) NTYPE=5
      IF(HOUSE) NIND=NINDP
      IF(HOUSE) IMAX=IMAXP
      DO 750 IMPACT=1,NREG
      DO 750 JTYPE=1,NTYPE
      DO 350 IREG=1,NREG
      DO 350 IND=1,NIND
      JK=NIND*(IREG-1)+IND
      Y(JK)=CCOEFF(IREG,IMPACT,IND)*FA(IND,JTYPE)
      IF(KOST.NE.0) Y(JK)=CCOEFF(IREG,IMPACT,IND)*FY(IND,JTYPE)
350   CONTINUE
C
      IF(.NOT.HOUSE) GO TO 365
      DO 555 I=1,IMAX
      SUM=0.0
      DO 455  J=1,IMAX
455   SUM=SUM+E(I,J)*Y(J)
555   X(I)=SUM
      GO TO 560
365   DO 550 I=1,IMAX
      SUM=0.0
      DO 450 J=1,IMAX
450   SUM=SUM+D(I,J)*Y(J)
550   X(I)=SUM
560   DO 650 IREG=1,NREG
      DO 650 IND=1,NIND
      JK=NIND*(IREG-1)+IND
      YF(IREG,IND)=Y(JK)
650   XF(IREG,IND)=X(JK)
      DO 950 IND=1,NIND
      SUM=0.0
```

```
      SUMY=0.0
      DO 850 IREG=1,NREG
      SUMY=SUMY+YF(IREG,IND)
850   SUM=SUM+XF(IREG,IND)
      YF(NREG+1,IND)=SUMY
950   XF(NREG+1,IND)=SUM
      DO 951 IREG=1,NREGP
      SUM=0.0
      SUMY=0.0
      DO 851 IND=1,NIND
      SUMY=SUMY+YF(IREG,IND)
851   SUM=SUM+XF(IREG,IND)
      YF(IREG,NIND+1)=SUMY
951   XF(IREG,NIND+1)=SUM
      WRITE(IOUT,2100) IMPACT,JTYPE
      WRITE(IOUT,2101)
      CALL PRINTB(YF,NREGP,NIND+1,IOUT,2)
      WRITE(IOUT,2200) IMPACT,JTYPE
      WRITE(IOUT,2101)
      CALL PRINTB(XF,NREGP,NIND+1,IOUT,2)
750   CONTINUE
C
2100  FORMAT(1H1,///T10,'REGIONAL FINAL DEMAND: IMPACT REGION =',
     >I5,5X,'TYPE =' I5,///)
2200  FORMAT(1H1,///T10,'OUTPUT : IMPACT REGION =',I5,5X,'TYPE =',I5///)
2101  FORMAT(//2X,'INDUSTRY',T21,'R1',T36,'R2',T51,'R3',T66,'R4',T78,
     >'NATION'//)
      RETURN
      END
      SUBROUTINE DEMAND(KOST,FY)
C******DEMAND
C
C     TO COMPUTE THE FINAL DEMAND VECTORS PER $1.000 PROJECT COSTS FOR
C     A CLOSED INPUT-OUTPUT MODEL USING 1958 DATA WITH DEFLATOR
C
      DOUBLE PRECISION SUM
      DIMENSION IND(84),FX(84,12),FY(12,5),SUM(12),TOTAL(12)
      COMMON /BK1/FD(84,12),DEFL(84),M,N,IOUT,INP
      COMMON /BK2/FA(12,12)
      DATA NR,NC/84,12/
      M=NR
      N=NC
      MN1=M-1
C
C         READ AND WRITE INPUT FILE
```

```
C
      WRITE(IOUT,100)
      DO 10 I=1,M
      READ(INP,200) IND(I),(FX(I,J),J=1,N)
      DO 5 J=1,8
5     FD(I,J)=FX(I,J)
      DO 6 J=9,11
6     FD(I,J)=FX(I,J+1)
      FD(I,12)=FX(I,9)
      WRITE(IOUT,600)IND(I),(FD(I,J),J=1,N)
10    CONTINUE
C
      WRITE(IOUT,300)
      DO 20 I=1,MN1
      READ(INP,400) IND(I),DEFL(I)
      WRITE(IOUT,400) IND(I),DEFL(I)
20    CONTINUE
C
C        COMPUTE THE NATIONAL FINAL DEMAND FOR 1963
C
      DO 25 I=1,MN1
      DO 25 J=1,N
      FD(I,J)=FD(I,J)*DEFL(I)/100.0
25    CONTINUE
C
C        AGGREGATION IN ORDER TO MAKE 10 INDUSTRIES
C
      CALL AGGRGT
      M=12
      MN2=M-2
      DO 35 J=1,N
      SUM(J)=0.0
      DO 45 I=1,MN2
45    SUM(J)=SUM(J)+FA(I,J)
      FA(M,J)=SUM(J)
      TOTAL(J)= FA(M,J)+FA(M-1,J)
35    CONTINUE
      DO 55 I=1,M
      DO 55 J=1,N
55    FA(I,J)=FA(I,J)*1000.0/TOTAL(J)
C
C        WRITE OUTPUT
C
      WRITE(IOUT,500)
      DO 30 I=1,M
```

```
30     WRITE(IOUT,600) IND(I), (FA(I,J),J=1,N)
C
C          COMPUTE THE NATIONAL FINAL DEMAND FOR GIVEN PROJECT AND
C                CONTRACT COST
C
       CALL CONTRC(KOST,FY)
C
100    FORMAT(1H1,///T5,'NATIONAL FINAL DEMAND VECTORS IN 1958'///)
200    FORMAT(I10,7F10.2/(5F10.2))
300    FORMAT(//T5,'DEFLATOR'//)
400    FORMAT(I5,F15.2)
500    FORMAT(1H1,///T5,'NATIONAL FINAL DEMAND VECTORS IN 1963'///
      >T10,'PER $1,000 PROJECT COSTS FOR A CLOSED INPUT-OUTPUT MODEL'//)
600    FORMAT(I10,12F9.2)
       RETURN
       END
C*****AGGRGT
C
       SUBROUTINE AGGRGT
C
C          AGGREGATION OF 79 INDUSTRIY SECTORS INTO 10 SECTORS
C                HOUSEHOLD SECTOR INCLUDED
       DOUBLE PRECISION SUM
       DIMENSION L(13)
       COMMON /BK1/FD(84,12),DEFL(84),M,N,IOUT,INP
       COMMON /BK2/FA(12,12)
       DATA NCOL,NROW/12,12/
       NROWP=NROW+1
       READ(INP,100)    (L(K),K=1,NROWP)
       WRITE(IOUT,200)(L(K),K=1,NROWP)
       DO 30 J=1,NCOL
       DO 20 K=1,NROW
       M1=L(K)
       M2=L(K+1)-1
       SUM=0.0
       DO 10 I=M1,M2
10     SUM=SUM+FD(I,J)
20     FA(K,J)=SUM
30     CONTINUE
100    FORMAT(13I5)
200    FORMAT(///13I5///)
       RETURN
       END
C*****CONTRC
C
```

```
      SUBROUTINE CONTRC(KOST,A)
C         KOST=0        NO COMPUTATION  FOR CONTRACT COST OR PROJECT COST
C         KOST=1        CONTRACT COST ONLY
C         KOST=2        PROJECT COST ONLY
C         KOST=3        BOTH COST ARE USED BUT RETURNED VALUES ARE
C                       PROJECT COST
      DIMENSION B(12,4),A(12,5),CCT(5),ALPHA(5),PC(5),SUMCOL(84)
      COMMON /BK1/FD(84,12),DEFL(84),M,N,IOUT,INP
      COMMON /BK2/FA(12,12)
      IF(KOST.EQ.0) GO TO 999
      NN=4
      NNP=NN+1
      MN1=M-1
      MN2=M-2
      MHALF=M/2
      READ(INP,100) (CCT(J),J=1,NNP)
      WRITE(IOUT,110)
      WRITE(IOUT,100)(CCT(J),J=1,NNP)
      READ(INP,150) (ALPHA(J),J=1,NN)
      WRITE(IOUT,150)(ALPHA(J),J=1,NN)
      WRITE(IOUT,120)
      READ(INP,100) (PC(J),J=1,NNP)
      WRITE(IOUT,100)(PC(J),J=1,NNP)
C
      DO 10 I=1,M
      B(I,1)=FA(I,1)
      B(I,2)=FA(I,5)
      B(I,3)=FA(I,8)
      B(I,4)=FA(I,11)
10    CONTINUE
      IF(KOST.EQ.2) GO TO 68
C
C         CONTRACT COST
C
      ICOUNT=1
      DO 20 I=1,M
      DO 20 J=1,NN
      A(I,J)=B(I,J)*CCT(J)/1000.0
20    CONTINUE
25    DO 40 I=1,M
      SUMCOL(I)=0.0
      DO 30 J=1,NN
30    SUMCOL(I)=SUMCOL(I)+A(I,J)
40    A(I,NN+1)=SUMCOL(I)
      TOTAL1=0.0
```

```
      DO 50 I=1,MN2
50    TOTAL1=TOTAL1+SUMCOL(I)
      ERROR=TOTAL1-A(M,NN+1)
      IF(ICOUNT .EQ. 1) WRITE(IOUT,200)
      IF(ICOUNT .EQ. 2) WRITE(IOUT,250)
      WRITE(IOUT,300)
      DO 60 I=1,M
      WRITE(IOUT,400) I,(A(I,J),J=1,NNP)
60    CONTINUE
      WRITE(IOUT,500) A(M,NN+1),TOTAL1,ERROR
      IF(ICOUNT .EQ. 2) GO TO 999
      IF(KOST.EQ.1) GO TO 999
C
C        PROJECT COST
C
68    ICOUNT=2
      DO 70 I=1,M
      DO 70 J=1,NN
      A(I,J)=B(I,J)*PC(J)*ALPHA(J)/1000.0
      IF(I .EQ. MN1) A(I,J)=A(I,J)+PC(J)*(1.0-ALPHA(J))
70    CONTINUE
      GO TO 25
100   FORMAT(5F15.4)
110   FORMAT(///T10,'CONTRACT COST')
120   FORMAT(///T10,'PROJECT COST')
150   FORMAT(4F10.5)
200   FORMAT(1H1,///T8,'NATIONAL FINAL DEMAND VECTORS FOR THE MCLELLAN-
     >KERR ARKANSAS RIVER'/T21,'MULTIPLE PURPOSE PROJECT CONTRACT COST*
     >'//T27,'( UNIT $1,000 1963 PRICES)'///)
250   FORMAT(1H1,///T8,'NATIONAL FINAL DEMAND VECTORS FOR THE MCLELLAN-
     >KERR ARKANSAS RIVER'/T21,'MULTIPLE PURPOSE PROJECT COSTS*
     >'//T27,'( UNIT $1,000 1963 PRICES)'///)
300   FORMAT(T8,'PROJECT',T17,'MULTIPLE',T30,'FLOOD',T43,'REVETMENTS',
     >T56,'LOCK & DAMS',T69,'TOTAL'/T8,'CATEGORY',T19,'PURPOSE',T33,
     >'CONTROL',T72,'PROJECT'/2X,'I-O SECTOR'/)
400   FORMAT(I8,7X,5F13.2)
500   FORMAT(1H3,2F20.2,F10.4)
999   RETURN
      END
/*
```

Appendix A

Tape Operation for UNIVAC 1108

(1) To write or read a tape,

CALL NTRAN(Unit,Opr,Size,Name,LAY,22)

where

Unit: logical unit number

Opr = 1 for write on a tape

= 2 for read a tape

Size: the size of a matrix (mxn) will be mn

Name: the name of variable

(2) To rewind a tape,

CALL NTRAN(Unit, Opr,22)

where

Unit: logical unit number

Opr = 10 for rewind

(3) To assign a tape for reading,

@ASG,TJ Unit.,8C,Tapeid

where

J: option for label

Unit: logical unit number

Tapeid: tape I.D.

8C: physical unit number

(4) To assign a tape for writing,

@ASG,TJ Unit.,8C,Tapeid W

where

W: for enabling writing

Appendix B

Inverse Matrix and its Submatrices

The direct and indirect and induced requirement is computed by inverting I-TA. The inverse matrix, E, is a 320x320 square matrix.

$$(I-TA)^{-1} = E(320x320) = \begin{vmatrix} G_{11} & G_{12} & G_{13} & G_{14} \\ G_{21} & G_{22} & G_{23} & G_{24} \\ G_{31} & G_{32} & G_{33} & G_{34} \\ G_{41} & G_{42} & G_{43} & G_{44} \end{vmatrix}$$

where

$$G_{ij} = \begin{vmatrix} e_{11} & e_{12} & e_{13} & \cdots & e_{1n} \\ e_{21} & e_{22} & \cdots & & e_{2n} \\ \vdots & \vdots & & & \vdots \\ e_{n1} & e_{n2} & \cdots & & e_{nn} \end{vmatrix}, \quad n=80$$

DATA9 is stored on a tape as shown in figure.

File 1	File 2	File 3	File 4	File 5	. . .	File 16
G_{11}	G_{12}	G_{13}	G_{14}	G_{21}	. . .	G_{44}

APPENDIX D

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